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No. 59

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USSR REPORT

PHYSICS AND MATHEMATICS

No. 59

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CONTENTS PAGE

ACOUSTICS

Scientists Receive Award for Microwave Development
(I. Kirpichnikova; SOVETSKIY VOIN, Sep 79) 1

NUCLEAR PHYSICS

Future Work on Development of Thermonuclear Energy
(A. Ivakhnov; IZVESTIYA, 11 Oct 79) 6

ABSTRACTS

Acoustics 10
Crystals and Semiconductors 12
Fluid Dynamics 22
Lasers and Masers 23
Nuclear Physics 41
Optics and Spectroscopy 42
Optoelectronics 47
Superconductivity 49

ACOUSTICS

SCIENTISTS RECEIVE AWARD FOR MICROWAVE DEVELOPMENT

Moscow SOVETSKIY VOIN in Russian No 18, Sep 79 pp 28-29

[Article by I. Kirpichnikova]

[Text] The young scientists are eight in number. They all work at the Leningrad Institute for Aviation Instruments. Viktor Bogdanov is a senior laboratory technician, Sergey Zabuzov and Aleksandr Litvinenko are senior scientific workers, Vladimir Zibarov and Aleksandr Kiryukhin are lead engineers, and Vladimir Nititin and Nikolay Chernyshev are senior engineers. Boris Pirogov is an assistant. In 1977, they were awarded the Lenin Komsomol Prize for research and development work on functional microwave acoustic devices for radio systems.

Whenever they get together, it is immediately apparent how different they are, one from another. One of them has the stern, watchful eyes of a person used to subjecting everything to detailed analysis. Another has an open, smiling face. A third is quiet, does not use many words and, it seems, is unhappy that he has been taken away from his work. And this round-faced youth gives the impression of a sociable or, as it is put today, a with-it person.

Their teacher is the head of the department for radio electronics, Georgiy Konstantinovich Ul'yanov. It was he who instilled in the young scientists the love for acoustoelectronics, a new and most promising science.

During the last century, the English physicist, Rayleigh, certainly could not suspect the practical consequences of his theory. Especially in his famous monograph, "Theory of Sound," he described in detail the nature of the so-called surface acoustic waves and studied in a purely theoretical way the possibilities for their propagation in solid bodies.

Seismologists were the first to encounter the surface waves in practice, when they learned how to analyze signals from various earthquakes. But of greatest interest were acoustic studies of the surface finish on complex surfaces. These studies were begun at the Leningrad Ship Construction Institute. Methods for detecting various defects in metal surfaces, such as fractures, foreign inclusions, and coarse finishing, were first worked out here. These studies were carried out by using an acoustic signal propagating along the surface.

A young engineer-designer participating in these studies was G. Ul'yanov. In his dissertation, he developed the general principles for using acoustic surface flaw detection. He continued his scientific research after he transferred to the Leningrad Institute for Aviation Instrument Construction. Here he studied the quality of welds by using the laws of acoustics. Such studies, it seemed at that time, were not "within the purview" of the aviation branch. Colleagues in the instrument field understood that these studies would apply in the future. They supported the scientist.

At first, he was assigned two assistants from among the graduates of the institute. This was the first specialized group of researchers. They were given a specific task: To develop an acoustic device to be used as the main memory or core store of an electronic computer.

They were starting, so to speak, from zero, as there were no equipment nor special materials for this small research group. But there was an idea in which they believed. And a great desire to find the best design for the computer memory element. They immediately ran into difficulties: For a long time, they were unable to obtain a pure surface acoustic wave.

The researchers were using the piezoelectric effect. In the design developed by G. Ul'yanov with his scientists, the wave originated in a piezoelectric plate, which was glued to the inclined facet of a polystyrene prism.

In this fashion, a body wave was generated in the prism.

The inventors treated their offspring with a sufficient degree of objectivity. They well understood that the design was still imperfect. And they were not surprised when ferrite components were selected for use as memory elements in electronic computing machines.

However, under laboratory conditions and for research purposes, the prism generator was completely acceptable. For it produced, so to speak, Rayleigh waves in pure form. (They are now abbreviated as PAV, or surface acoustic wave.) Students of the electronics department were now in a position to perform experiments by generating these very same PAVs.

The scope of research work in the acoustic field gradually began to expand. G. Ul'yanov's group received more members from the graduates of the aviation institute as well as a laboratory. The researchers were given the specific task: To determine the feasibility of using the properties of Rayleigh waves in navigation.

The generation and processing of such complex signals was something that the position-finding and navigation equipment of that time could not do adequately. Entirely new approaches were required. Was it possible that the solution was in using Rayleigh waves?

It was suggested to G. Ul'yanov that he develop a broad study with the needs of aviation in mind. There were almost no specialists in this new field of science, where it was necessary to merge acoustics and radioelectronics.

Again, capable youth had to be attracted. Once again, there were additions to the research group. Among them were our eight young specialists, who subsequently became recipients of the Lenin Komsomol Prize. Various branches of industry became interested in the work of the laboratory. There was literally no let-up of orders.

The study of all facets of the piezo effect helped G. Ul'yanov and his new scientists to create original devices employing surface acoustic waves. The young scientists were able to prove that the apparently simple device could solve a multitude of problems. It was primarily because in using this device with other instruments it was possible to sort out various signals more precisely and more accurately.

Terrestrial radio services often have difficulty in separating signals that originate simultaneously from many radio stations. It is also necessary that the response go back to that party requesting it. Also, it is required that the desired signal and the response be filtered to remove extraneous noise. This task was entrusted to Boris Pirogov.

If the energy of a transmitted signal is not large enough, it can "drown" in the extraneous noise. A filter can separate the required signal from any environment. However, in order that the complete signal arrive, it would be better to compress the wave initially. What does that mean? Let us try to understand it.

Picture this fantastic image. Multicolored waves are chasing one another across the surface of the sea. Along the way, they meet some obstacle that changes them. When they hit the obstacle, the waves start building one on top of the other and form a single, large wave, which takes into itself their entire power without disturbing the coloring. Beyond the obstacle, only a single narrow but high wave will be moving, and it will occupy only a small space.

Afterward, it is possible to spread out the compressed wave again and to isolate from among all the pulses precisely the one that was transmitted initially.

Boris Pirogov received a patent for the invention and perfection of filters for PAVs.

For aircraft navigational systems, a surface wave device was required that would make it possible to fix rapidly the phase shift between two radio signals. Sergey Zabuzov and Aleksandr Kiryukhin took it upon themselves to perform precise experiments and to select the necessary design for the electrodes.

This work was extremely tedious. For this work, it is not enough to do it once thoroughly; it requires a jeweler's precision and great proficiency. These characteristics, which were possessed by Sergey and Aleksandr, made it possible for them to achieve success in the design of new phase meters. The devices created by Zabuzov and Kiryukhin were also acknowledged by patents issued by the State Committee for Inventions and Discoveries.

In order to make it easy to assign the required functional designations to the new acoustic microwave devices, the young colleagues found it necessary to study the structure of these signals precisely and in great detail. Zabuzov, Litvinenko, and Kiryukhin proposed and then patented a device that, similarly to an optical spectrum, decomposes an arbitrary radio signal into a specific acoustic rainbow. Having transformed radio waves into acoustic waves, the spectral analyzer distributes various tones as a function of time. For example, it first shows the low tones, then it shows higher ones and then again low ones and so on.

Acoustic spectral analyzers used up to this time operated as follows: First, a single tone was searched for in the signal, then the signal was repeated and a second tone was searched for in its acoustic range. Then the cycle was repeated and so forth. This required much time. Besides, some fine points of semitones could be easily missed in such a procedure.

The new analyzer gives the full breakdown of all phases of the acoustic rainbow in one pass. The young engineers (each in his narrow sphere) became talented designers and together they created a promising outlook for acoustoelectronics. Vladimir Nikitin, for example, has developed programs that can be used to determine the configuration of widely varied electrodes with micron accuracy. The practical construction of all acoustic instruments, however, fell to Viktor Bogdanov. For this he had to master the difficult craft of working with optical equipment.

And yet, no matter how precisely a new instrument is constructed, it is impossible to guarantee fully an absence of errors. For this reason, it was necessary to work out a complete theory of errors for acoustic devices. Vladimir Zibarov, the author of this theory, reckons that maximum reliability must be provided in developing and producing equipment that works on the Rayleigh waves. Then it would be unnecessary to adjust and repair the instruments.

The advantages of devices using PAVs, which were created by the young Leningrad scientists, were quickly evaluated on their merits.

Through the efforts of the young scientists, a unique research laboratory for microwave acoustic devices was established, which was demonstrated at the exhibit of achievements of the national economy of the USSR and was awarded a gold medal. During a relatively brief time, the group of researcher-prize-winners was able to develop dozens of acoustic devices for various functional purposes. The new instruments have already been introduced into many enterprises. The annual economic benefits from their introduction represent about R4 million.

But even more intriguing are the new designs by the young scientists.

There is a bright outlook for acoustic communication devices. The scientists are trying to remove all tubes, cables, and semiconductors, and assign these functions to structural crystal lattices. Then it will no longer be necessary to create complex systems.

For the scientists, such a task seems easy to achieve today!
[26-6948]

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NUCLEAR PHYSICS

FUTURE WORK ON DEVELOPMENT OF THERMONUCLEAR ENERGY

Moscow IZVESTIYA in Russian 11 Oct 79 p 2

[Article by A. Ivakhnov, Special Correspondent of IZVESTIYA: "Future Energy is Being Born: At the Institute of Atomic Energy imeni I. V. Kurchatov Yet Another Step Has been Made on the Path Toward Synthesizing Controlled Thermonuclear Fusion"]

> [Text] Scientists hope that within the next five years it will be possible to achieve controlled thermonuclear fusion at the Soviet Angara-5 facility. That facility will consist of 48 modules--giant electron "guns" aimed at a walnut-sized target. Inside the target is a mixture of nuclei of the isotopes of hydrogen--deuterium and tritium. All the "guns" will fire simultaneously. The combined power of the 48 electron beams will surpass the combined power of all the electric power stations in the Soviet Union. Within a few billionths of a second the target will be heated to hundreds of millions of degrees Centigrade. This is sufficient to assure the fusion of the nuclei. The released energy should exceed the energy expended on initiating the thermonuclear fusion.

A prototype of such a module, the Angara-1, was developed and built at the Institute of Atomic Energy imeni I. V. Kurchatov five years ago. It consists of an energy accumulator--a pulsed-voltage generator--on whose 20 "floors" are installed parallel-connected industrial capacitors, and an election accelerator which externally resembles several different-sized cylinders lying on their sides and overlapping each other; the initial cylinder is man-sized, while the final one, from where the electron beam emerges, could surely be encircled with one's hands. The entire facility occupies a single room--a large one, to be sure. I was shown metal plates in which holes were drilled by the electron beam. In experiments with the Angara-1 experts learned to control that beam and determine its parameters.

This year, in accordance with one of the tasks of a complex program which is among the 200 programs for the solution of the principal scientific and technical problems of the 10th Five-Year Plan period, it was decided to accomplish the physical start-up of the first experimental module of the Angara-5 facility. The crews participating in the fulfillment of this task adopted socialist labor competition pledges to carry it out ahead of schedule. And so now the module is ready for operation. In principle it resembles the electron accelerator of the Angara-1 facility, but it differs in power and dimensions, occupying a large hall consisting of several multi-meter bays. From the second-floor balcony extending alongside that hall the accelerator has a particularly impressive appearance, somehow resembling the Salyut-6 orbital station, except that it is even larger. To facilitate the assembling and operation of the facility, each subunit of the accelerator rests on a trolley and all the trolleys stand on tracks. The control panel of an Angara-5 module alone occupies about as much room as the whole Angara-1. One can visualize the size of the entire facility (whose mockup, incidentally, is now being displayed in the Physics Pavillion of the USSR All-Union Exposition of Achievements of the National Economy, where 48 such machines will be aligned fanwise in two stages around a reactor within which thermonuclear microexplosions will reverberate....

On the eve of the physical start-up of the module, correspondents of central newspapers and TASS met with the Deputy Director of the Institute of Atomic Energy imeni I. V. Kurchatov. Corresponding Member of the USSR Academy of Sciences Valeriy Alekseyevich Legasov.

The scientist declared: "First of all, I would like to discuss energy problems and how we look at them.

"In the history of mankind the traditional sources of energy have been supplanted with newer and better sources several times. And all this happened not because the old source was exhausted. Once man had no other source of heat and light than the Sun, and no one had ever conceived the idea that that luminary may extinguish itself some day, but nevertheless man learned how to use fire and began to burn wood. At the same time, a qualitative change took place in the development of civilization: fire can be used to cook food, and as a result men's habitations became warm. Subsequently, firewood gave place to black coal. Not because the timber resources became depleted, but because the new fuel was needed for steam machinery. Some time had passed, and black coal gave up its leadership on the energy market to petroleum. That was another advance in the development of civilization: aircraft and automobiles made their appearance, ships changed completely, and industry began to develop more actively. And yet the earth's reserves of petroleum are about only one-tenth as large as its reserves of black coal. Clearly, the point is not the total reserves of one energy source or another, but the cost effectiveness of its extraction and transportation to users as well as the convenience of its use. And the replacement of energy sources cannot be compared to, say, burning a new pile of logs after the previous pile had been burned. The question must be viewed much more broadly--this concerns the natural process of the growth of civilization.

"And so at present we happen to be living during a period of transition to yet another energy source. These days the leading types of fuel are petroleum and gas. But the extraction of every additional cubic meter of gas or every additional ton of crude requires a continually greater northward or eastward development of deposits and a continually deeper advance into the depths of the earth, and hence petroleum and gas will cost us more and more with each year.

"With what, then, can the existing energy sources be replaced? At present the pretenders to leadership in this plane are nuclear sources. The reserves of uranium are small--fewer than a ten-thousandth fraction of the reserves of coal. But per unit weight they contain a million times as much energy as does coal. Hence, the generation of the same amount of energy at atomic power stations requires only one-hundredth as much labor and resources than does the extraction of energy from coal. This accounts for the superiority of nuclear sources.

"One more important factor is that, inasmuch as the fission of uranium nuclei entails the formation of radioactive fragments, the atomic "furnace" itself should be of an extremely hermetically sealed design so as to prevent the escape of these products in anyway whatsoever. And once such hermeticity has become technically feasible, we have an energy source which does not cause environmental pollution. That is another reason why many countries are now converting to nuclear fuel.

"But the reserves of uranium are not limitless. Moreover, reactors at present do not use all of uranium but only its one isotope--uranium-235, of which not more than one percent is contained in the overall mass of that element. There are two paths along which the search for new energy sources can proceed. One path is the development of atomic power stations which could burn not just one uranium isotope but all uranium. The other path is the attempt to achieve not the fission energy of heavy uranium nuclei but the fusion energy of light nuclei of hydrogen isotopes--deuterium and tritium. Deuterium is present on earth in extreme abundance--it is contained in seawater and its extraction is not very expensive, and there is no need to search for its deposits, since it is always at hand.

"The attainment of a controlled thermonuclear reaction requires the satisfaction of two conditions: First, a temperature of roughly 100 million degrees Centigrade must be attained; And second, the product of the nuclear concentration density and the time interval of that temperature should exceed a specified quantity. That is, either a fairly rarefied gas is heated within, say, one second--which to physicists is a long interval of time--or a dense blob of deuterium and tritium, a tablet, gets heated within billionths of a second. The tokamak-type facilities will operate in accordance with the former principle, and the Angara-type facilities, in accordance with the latter.

"The heating of nuclei to such gigantic temperatures can be achieved in two ways: with the aid of laser radiation, or with the aid of charged-particle beams. The Angara-type installations will use the latter. From the engineering standpoint, this type of heating seems to us more simple and reliable. All the 48 modules of the thermonuclear facility are identical, and if the first of these, whose start-up we are now readying, yields its share of energy, this means that we are on the right road and that the Angara-5 facility can be adapted to the conditions required for controlled thermonuclear reactions. The operation of the future industrial thermonuclear facilities can be visualized as a sequence of explosions of deuterium-tritium tablets, each yielding its share of energy--and taken together, these "portions" will coalesce into a continuous energy flux. But that, of course, is not a matter of the immediate future. For the time being we are just readying the physical start-up of the first module of the facility in order to check its performance quality. After all, a controlled thermonuclear reaction is an extraordinarily complex thing and has to be approached without haste, step by step...."

Further, Valeriy Alekseyevich pointed out that the personnel of many institutes and enterprises took part in the development and construction of the experimental module. The principle equipment of the module was designed and built at the Scientific Research Institute of Electrophysical Apparatus imeni D. V. Yefremov and at the Dvigatel' Engine Plant. The complex automation system indispensable to the operation of the facility was developed by experts from the All-Union Scientific Research Institute of Instrument-Making. Now that the module is ready, it can be proudly stated that our science and industry have coped with their task.

Scientists, engineers, and workers participating in the development of the thermonuclear module have fulfilled their pledge. The physical start-up of the innovation took place on schedule. At the Institute's meeting devoted to the start-up, the President of the USSR Academy of Science Academician A. Aleksandrov delivered an address. He declared that the start-up of the first module of the Angara-5 is a major step forward on the path toward mastery of truly inexhaustible energy sources.
[44-1386]

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ACOUSTIC CHARACTERISTICS OF LASER BREAKDOWN IN TRANSPARENT DIELECTRICS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 6, No 8, Aug 79 pp 1730-1734
manuscript received 12 Dec 78

ASHMARIN, I. I., BYKOVSKIY, Yu. A., GRIDIN, V. A., ZYSIN, Ya. Yu.,
IVANOV, A. Yu., YUDIN, S. I., Moscow Engineering Physics Institute

[Abstract] An investigation is made of a pressure wave propagating through a material from a laser breakdown focus in a transparent dielectric. It is shown that the wave structure at great distances from a source is determined by the conditions of its formation and is associated with the energy characteristics of the source and the properties of the material, and that the investigation of this structure may yield information on the source of the wave. An experimental study is done on the space-time structure of a compression wave as a function of the distance from the source of laser breakdown and the energy of the initiating emission. Theoretical and experimental results are compared and shown to agree qualitatively and quantitatively. The authors thank A. S. Aleksandrov for constructive criticism. Figures 5, references 6: 4 Russian, 2 Western.
[24-6610]

INFLUENCE OF SURFACE WAVES ON REFLECTION OF SOUND FROM A ROUGH SURFACE

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 77
No 3(9), Sep 79 pp 1175-1182 manuscript received 12 Apr 79

URAZAKOV, Ye. I. and FAL'KOVSKIY, L. A., USSR Academy of Sciences Institute of Theoretical Physics imeni L. D. Landau

[Abstract] An experimental curve taken from an earlier study (1966) is shown, illustrating the dependence of the coefficient of reflection of ultrasound incident from a liquid onto the surface of a solid, on the angle of incidence, where the angle of reflection is equal to the angle of incidence. In the region of total reflection, when body sound waves cannot be propagated in the solid, a minimum exists whose position and form depend on the properties of the surface. This fact is of interest from the practical viewpoint, in particular, as one method of nondestructive testing. The origin of the minimum observed is associated with the excitation in the solid of surface waves. These waves are similar to Rayleigh waves propagated along the surface of a solid bounded by a vacuum. When the solid is bounded by a liquid the surface waves are attenuated because of radiation into the liquid. In spite of this radiation, for an ideally

flat surface the reflection coefficient must become unity in the same region in which the excitation of surface waves is possible. Detailed consideration is given here to the reflection of sound incident from a liquid onto the rough surface of an isotropic solid. It is found that with angles of incidence consistent with total internal reflection the reflection coefficient has a distinct minimum caused by the excitation of surface waves. This minimum is extreme in the case of roughness which is minor as compared with the sound's wavelength and of mild roughness. The reason for this is competition between roughness and the low ratio of the acoustic impedance of the liquid and solid. The position and form of the minimum are studied in relation to the frequency of the sound and roughness parameters. The assumption is made that the surface studied is flat on average, and that the mean level of irregularities is low as compared with the normal component of the sound's wavelength (relative to the surface) and as compared with the distance along the surface, on which the roughness varies considerably. These conditions make it possible to expand the boundary conditions in a series in terms of the surface's deviation from an ideally flat one, as is usually done in the familiar method of minor perturbations. By this method it is possible to study the influence of the roughness on the passing wave in a similar manner to how the reflection coefficient is considered. Figures 2; references 7: 5 Russian, 2 Western.
[31-8831]

USSR UDC 621.315.592

EFFECT OF ELECTRON BOMBARDMENT ON THE ELECTROPHYSICAL PROPERTIES OF GERMANIUM-SILICON SOLID SOLUTIONS

Baku DOKLADY AKADEMII NAUK AZERBAYDZHANSKOY SSR in Russian Vol 35, No 4, 1979 pp 29-31 manuscript received 25 Dec 78

BAKIROV, M. Ya., ABIYEV, A. K., ABBASOV, Sh. M. and GASUMOV, G. M., Radiation Research Sector, Academy of Sciences of the Azerbaijanian SSR

[Abstract] An experimental study was made of the effect of electron bombardment on the continuous system of p-type solid solutions over the 0-15 atom.% Si range. Specimens of single crystals with 0, 8.10 and 15 atom.% Si respectively were grown by the Czochralski method, their initial hole concentration ranging from $1.5 \cdot 10^{14}$ to $1.97 \cdot 10^{15}$ cm^{-3}. Their electrical conductivity and Hall coefficient were measured at temperatures from 77 to 500 K before and immediately after bombardment with 3.5 MeV electrons, also after subsequent annealing at 420 K. According to the data, electron bombardment increases the Hall mobility and lowers the hole concentration so that a reversal to n-type conduction occurs at some temperature which becomes higher with increasing silicon content. An anomalous behavior of some specimens with a lower silicon content after annealing may be due to a nonuniform distribution of silicon atoms or due to establishment of a radiation level within the forbidden band. The results indicate the feasibility of controlling the properties of germanium-silicon alloys by varying the dose of electron bombardment. The article was presented by academician (Academy of Sciences of the Azerbaijanian SSR) L. M. IMANOV. Figures 2; references 6: 5 Russian, 1 Western.
[55-2415]

USSR UDC 539.2

CONCERNING A POSSIBLE CAUSE FOR INCREASED SOLUBILITY IN SMALL PARTICLES

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 247, No 6, 1979 pp 1376-1380 manuscript received 4 Jun 79

MOROKHOV, I. D., CHIZHIK, S. P., GLADKIKH, N. T., GRIGOR'YEV, L. K. and STEPANOVE, S. V., Moscow Institute of Aviation Technology imeni K. E. Tsiolkovskiy

[Abstract] The phase composition, substructure and physicochemical properties are different in massive and fine specimens of the same metals at the same temperatures. The increased solubility in small particles and condensed films is attributed chiefly to the particulars of producing

such highly dispersed systems, for example intense supercooling and supersaturation in the case of condensed films, i. e. the effect is explained mainly by kinetic parameters. However, the particulars of condensation alone cannot explain the observed solubility of components or the dependence of solubility on islet size or film thickness. Observed differences in the behavior of small particles as compared with massive specimens can be explained in an uncontradictory way if one accounts for the difference in the equilibrium concentration of vacancies in specimens of small dimensions as compared with a bulk specimen, leading to a vacancy mechanism of the size effect. It is shown that the concentration of vacancies is higher in small particles than in massive specimens, and that this concentration increases with a reduction in particle size. Thus the solubility increase can be explained by the fact that vacancies capture atoms of the dissolved substance. Figures 2, references 14: 12 Russian, 2 Western.
[20-6610]

USSR UDC 541.44

PHASE TRANSFORMATIONS IN THE Tc-H SYSTEM AT HIGH PRESSURE

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 247, No 6, 1979 pp 1420-1423 manuscript received 30 Mar 79

SPITSYN, V. I., Academician, PONYATOVSKIY, Ye. G., ANTONOV, V. Ye., BELASH, I. T., and BALAKHOVSKIY, O. A., Institute of Solid State Physics, Academy of Sciences USSR, Chernogolovka, Moskovskaya Oblast, Institute of Physical Chemistry, Academy of Sciences USSR, Moscow

[Abstract] An investigation is made of the solubility of hydrogen in technetium at 300°C and $P_H \leq 19$ kbar, the thermal stability and structure at P = 1 atm of Tc-H solutions produced at high pressure, and the behavior of isotherms of the electrical resistance of technetium at $T \leq 350^\circ C$ and P_{H_2} of the order of 15 kbar or less. Specimens were made from ^{99}Tc foil 0.05 mm thick. Temperature measurements were accurate within 5°C, and pressure measurements--within 5 kbar. The Tc-H specimens for chemical and x-ray analysis were made by holding the foil at 300°C at the given hydrogen pressure for 5 hours. The chamber then was cooled to 0°C, pressure was reduced to atmospheric level, and the foil was removed from the chamber. The accuracy of determining the ratio n of hydrogen/metal was 0.05. For specimens saturated at a hydrogen pressure of 19 kbar, $n = 0.73 \pm 0.05$. Kinetic curves for a constant heating rate of 3°C/min show that the liberation of hydrogen becomes noticeable beginning at about 80°C, and at 300°C the dissociation of the hydride is practically complete. The kinetics of hydrogen release remains sluggish up to about 200°C. Dissociation of technetium hydride takes several months at room temperature and atmospheric pressure. Powder patterns showed that $TcH_{0.73}$ in a single-phase compound with hcp lattice. The lattice parameters are given for this

hydride, and also for hydrides of manganese and chromium, which also form interstitial phases with hcp lattice with hydrogen. Technetium hydride seems to be an analog of manganese hydride in both structure and thermal stability. Both these hydrides show a noticeable and nearly identical reduction in the ratio c/a with an increase of hydrogen concentration, whereas solutions of Co-H show almost no change in c/a with concentration. The authors thank K. A. Peresad and A. N. Grachev for constant assistance in preparing and doing the experiments. Figures 4, references 10: 6 Russian, 1 Polish, 3 Western.
[20-6610]

USSR UDC 539.1.03

RESONANT ACCELERATION OF CHANNELED PARTICLES IN THE FIELD OF A STRONG LIGHT WAVE

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 249, No 1, Nov-Dec 79 pp 100-102 manuscript received 9 Jul 79

BELOSHITSKIY, V. V. and KUMAKHOV, M. A., Scientific Research Institute of Nuclear Physics, Moscow State University imeni M. V. Lomonosov

[Abstract] The channeling effect offers an excellent method of controlling the trajectory of charged particles during their acceleration in a laser field. Here dechanneling of a particle due to multiple scattering and the effect of this on the acceleration process are analyzed on the basis of energy relations. Necessary electric field intensities and maximum attainable acceleration energies are established for positive particles, taking into account also the fragility of crystals. Considered is, furthermore, acceleration of relativistic particles due to resonant absorption of light according to the reverse Cherenkov effect. In strong accelerating fields (over 1 GV/cm) diffusion from a channel is found to be suppressed by a decrease of the emittance so that a thick crystal can be used. In the case of particles with low energies (under 0.1 MeV/nucleon) transverse motion is impeded by friction against electrons so that in an electric field of corresponding adequate intensity a beam can be collimated without an increase of energy. The article was presented by academician Ye. P. BELIKHOV on 18 May 79. References 5: 3 Russian, 2 Western.
[56-2415]

USSR UDC 548.736

CRYSTALLINE STRUCTURE OF POTASSIUM-ZINC-BERYLLIUM SILICATE $K_2Zn_2Be_2(SiO_4)(Si_2O_7)$

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 249, No 1, Nov-Dec 79 pp 103-105 manuscript received 6 Jul 79

BALKO, V. P., BAKAKIN, V. V., GATILOV, Yu. V. and PAVLYUCHENKO, V. S., Institute of Inorganic Chemistry, Siberian Division of the USSR Academy of Sciences, Novosibirsk

[Abstract] The crystalline substance $K_2Zn_2Be_2(SiO_4)(Si_2O_7)$ was produced at the Institute of Geology and Geophysics (Siberian Division of the USSR Academy of Sciences) by a hydrothermal reaction in the K_2O-BeO-ZnO-SiO_2-H_2O system. The specimen examined at the Institute of Inorganic Chemistry was faintly pink in color and $0.2 \times 0.1 \times 0.1 mm^3$ in size, with a rhombic crystal cell of the Imam group and an experimentally determined density of $3.23 g/cm^3$. Its structure was further examined with a Syntex-$P2_1$ diffractometer using MoK_o radiation and by standrad scanning. Data taken from sufficiently intensive 1616 out of 2192 total reflections were processed according to the MULTAN-XTL program with the optimum estimators. The structure has been found to be polyhedral, featuring not only the already well known silicioxyl biradical but also two kinds of cations (beryllium and zinc) in the tetrahedral envelope, with short contacts through a common oxygen bridge, as well as separate Be_2O_6 diortho-groups and Zn_2O_6 diortho-groups condensed into a $(Zn_4O_8)_\infty$ ribbon. The article was presented by academician N. V. BELOV on 6 Jul 79. Figures 2; tables 2; references 12: 5 Russian, 7 Western.
[56-2415]

HOT LUMINESCENCE IN GALLIUM SELENIDE

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 21 No 8, Aug 79 pp 2217-2222 manuscript received 8 Jan 79, after correction 20 Mar 79

BAGAYEV, V. S., BELEN'KIY, G. L., ZAYTSEV, V. V., SALAYEV, E. Yu. and STOPACHINSKIY, V. B., USSR Academy of Sciences Physics Institute imeni P. N. Lebedev

[Abstract] Processes are discussed which result in hot luminescence from excited states of direct free excitons in layered single crystals of gallium selenide. The results are discussed of experiments relating to a study of the low-temperature luminescence spectra of layered single crystals of gallium selenide in which in addition to radiation from the ground state of an excited exciton are observed lines corresponding to excited 2s, 3s and 4s states. Samples of GaSe grown by the Bridgman technique in the epsilon modification, primarily, were investigated. Measurements were made with the steady-state excitation of an He-Cd laser with a wavelength of 4416 Å and a power of approximately 10 mW at a temperature of 2 K. The signal was recorded photoelectrically, employing an FEU-79 photomultiplier, a PAR model 126 lock-in amplifier (a narrowband amplifier with a synchronous detector) and a KSP-4 recorder. The maximum excitation density was not higher than 1 kW/cm^2. Graphs are shown of radiation spectra which show lines characteristic of 2s, 3s and 4s excitons. Also plotted is the dependence of the energy position of the ground and excited states of a direct exciton on $1/n^2$, where n is the principal quantum number. The intensity of photon $\hbar\omega_2$ is approximately two orders of magnitude less than that of $\hbar\omega_1$. The ratio of the intensities of the radiation line of an exciton in the 1s and 2s states indicates the distinctly nonequilibrium nature of radiation from excited states, for with a temperature of 2 K the population of levels with $n > 2$ is negligibly low. This fact makes it necessary to consider radiation from excited states to be related to hot luminescence. Features of the band structure of GaSe are discussed, whereby it is demonstrated that at low temperatures all radiation of GaSe must be regarded as hot luminescence. This is obvious from comparing the typical radiation spectrum with the energy position of exciton states. The band structure suggested makes it possible to explain all experimental data on the kinetics of the photoluminescence of GaSe. Various mechanisms are discussed which can be responsible for the luminescence of free excitions from excited states of a direct excition, where n = 2, 3 and 4, with an optical excitation density of $I \gtrsim 1$ W/cm^2. It is demonstrated that the hot luminescence observed is evidently associated with the scattering of free excitons by defects in the crystal lattice. When the excitation density is increased above 100 W/cm^2, another mechanism becomes probable. This mechanism is explained in terms of the features of the band structure of gallium selenide. The resonant nature of exciton states at the center and at the edge of the Brillouin zone is considered responsible for this mechnnism. Indirect excitons having an energy somewhat less than that of direct excitons, of approximately 4 meV, as the result of inelastic collisions can be thrown into possible states of a direct exciton. With an optical excitation density of about 100 W/cm^2 inelastic collisions of indirect excitions from different valleys become probable, as the result of which one of the excitons is thrown into the n = 1, n = 2, ..., states of a direct exciton, and another decays radiatively, imparting an energy equal to the difference in the energies of the first exciton in the final and initial states. This second mechanism can be assisted by the first, for interaction with defects or impurities can be responsible for an increase in the probability of intervalley relaxation. The first mechanism proposes that in a crystal with a great number of defects the de-excitation of excitons from excited states is caused by the scattering of excitons by defects, which results in the flopover of free excitons into the photon branch. The two mechanisms suggested do not contradict one another. Figures 4; references 18: 6 Russian, 12 Western. [29-8831]

OSCILLATIONS OF THE RESONANCE COMBINATION LIGHT SCATTERING CROSS SECTION IN THE LONGWAVE REGION OF THE SPECTRUM IN POLAR SEMICONDUCTROS

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 21 No 8, Aug 79 pp 2430-2534
manuscript received 3 Apr 79

BELITSKIY, V. I. and GOL'TSEV A. V., USSR Academy of Sciences Physico-Technical Institute imeni A. F. Ioffe, Leningrad

[Abstract] A new kind of resonance Raman light scattering has been hypothesized in polar semiconductors--electron-phonon Raman scattering--which is related to many-phonon cascade processes and originates as a result of the following sequence: Primary radiation with a frequency of ω_ℓ produces an electron-hole pair; the electron (or hole) can successively radiate several longitudinal optical (LO) phonons, and then emit without annihilation with a hole (or electron) a quantum of secondary light with the simultaneous radiation or absorption of the LO phonon. The electron-phonon Raman scattering (EPRS) cross section is of a zero order in relation to the Fröhlich constant for the coupling of electrons or holes with LO phonons and has characteristic threshold features in relation to the frequency of the primary light, ω_ℓ, and secondary emission, ω_s. Unlike earlier studies, this paper takes into account the interaction of electrons and holes with acoustic phonons, as well as with LO phonons. This has resulted in a new phenomenon, viz., the origin of strong oscillations of the scattering cross section as a function of the frequency of the primary light, ω_ℓ, in the region of secondary emission frequencies of $\omega_s < \omega_{LO}$, where ${}_{LO}$ is the frequency of an LO phonon. A straight-band isotropic polar semiconductor is discussed and it is assumed that the interaction of electrons or holes with LO phonons is much stronger than interaction with acoustic phonons. The origin of oscillations of the EPRS cross section in polar semiconductors is considered for the case when the Frohlich constant equals $\alpha << 1$. The discussion is limited to a specific temperature range of $2v_0\sqrt{2m_e\hbar\omega_{LO}} << k_BT << \hbar\omega_{LO}$, where v_0 is the speed of sound in the crystal and m_e is the mass of an electron. The origin of strong oscillations remains valid even with $\alpha \simeq 1$. A necessary condition is the triviality of the dispersion of LO phonons and a cascade process for the movement of electrons or holes through the band. The mechanism for the origin of oscillations is similar to the mechanism for the origin of oscillations of photocurrent in these semiconductors when the frequency of the primary light is increased. Figures 2; references 5: 4 Russian, 1 Western.
[29-8831]

USSR UDC 621.373.5

GAIN OF ELECTROMAGNETIC RADIATION OF A SEMICONDUCTOR PLACED IN A MAGNETIC FIELD AND IN THE FIELD OF AN ULTRASONIC WAVE

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 6, No 8, Aug 79 pp 1786-1789
manuscript received 31 Aug 78

ALEKSANYAN, A. G., BOYAKHCHYAN, G. P. and MIRZABEKYAN, E. G., Institute of Radio Physics and Electronics, Academy of Sciences, Armenian SSR, Ashtarak

[Abstract] The gain of an electromagnetic wave is calculated in a semiconductor located in a magnetic field and in the field of an ultrasonic wave. It is shown that a gain of 1-500 can be achieved over a wide range of variations in parameters. Analytic expressions are derived for the way that the real part of the radio-frequency conduction depends on frequency for various pumping powers, ultrasonic wavelengths and temperatures of the specimen. The authors thank B. M. Gyurdzhyan for assistance in doing the computer calculations, and also I. A. Poluektov for useful discussions of the results. Figures 3, references 4 Russian.
[24-6610]

USSR UDC 548:539.21

GROWTH AND OPTICAL PROPERTIES OF MERCURY THIOGALLATE

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 6, No 8, Aug 79 pp 1807-1809
manuscript received 24 Jan 79

BADIKOV, V. V., MATVEYEV, I. N., PANYUTIN, V. L., PSHENICHNIKOV, S. M., REPYAKHOVA, T. M., RYCHIK, O. V., ROZENSON, A. E., TROTSENKO, N. K. and USTINOV, N. D.

[Abstract] An investigation is made of the $HgS-HgGa_2S_4$ phase diagram. It is shown that there is a region of solid solutions based on $HgGa_2S_4$. Optically homogeneous single crystals of mercury thiogallate are grown and used for measuring indices of refraction in the 0.55-11 μm band. A phase synchronism diagram is constructed for a frequency mixing process of the type $o + o \rightarrow e$ that shows the presence of synchronous interaction in the given wavelength band. The results show that such single crystals should be useful as an effective nonlinear material. Figures 4, references 3: 1 Russian, 2 Western.
[24-6610]

USSR UDC 621.396.538.8

SPATIAL MODULATION OF LIGHT IN A PHOTOSENSITIVE STRUCTURE MADE UP OF A LIQUID CRYSTAL AND AN INSULATED GALLIUM ARSENIDE CRYSTAL

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 6, No 8, Aug 79 pp 1810-1812
31 Jan 79

KOMPANETS, I. N., PARFENOV, A. V. and POPOV, Yu. M., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR, Moscow

[Abstract] The paper gives the results of an experimental study of photosensitive MDS structures in contact with a nematic liquid crystal. When gallium arsenide is used as the semiconductor and the orientational electro-optical effect in the liquid crystal is utilized, high energy sensitivity of the structure can be realized. The minimum level of helium-neon laser emission intensity on 633 nm that is needed for 180° phase modulation of light or for maximum optical contrast of the order of 100:1 was $5 \cdot 10^{-7}$ W/cm^2 at a switching energy of 10^{-8}-10^{-9} J/cm^2. Spatial resolution was at least 10-12 lines per millimeter. This structure can be used for input and conversion of optical information, including for visualizing infrared emission. The authors thank L. M. Blinov and V. V. Titov for furnishing the liquid crystals and for constructive criticism, A. A. Vasil'yev and P. D. Berezin for consultation in doing the experiments. Figures 3, references 5: 4 Russian, 1 Western.
[24-6610]

CYCLOTRON FREQUENCY SHIFT FOR ELECTRONS LOCALIZED ON THE SURFACE OF LIQUID HELIUM

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 77 No 2, Aug 79 pp 717-732 manuscript received 21 Mar 79

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[Abstract] A discussion is given of the possible reasons for the effect of the reduction in the cyclotron mass of surface electrons as a function of the strength of an external pressure-exerting electric field revealed in a previous detailed study of the phenomenon of cyclotron resonance in the case of free electrons localized on the surface of liquid helium. In the case of surface electrons localized in the vapor-liquid plane, this type of localization always occurs with a growth in the pressure-exerting field and a lowering of temperature and the surface of helium at the point of electron localization is self-consistently deformed. In turn, the deformation of the surface which originates acts as a potential well for the localized electron. The process of the localization of surface electrons is facilitated considerably by the inclusion of a strong magnetic field

normal to the surface of the helium. The effect of a perpendicular electric field on a charged spot on the surface of helium of finite dimensions will automatically result in deformation of the surface. The reduction in the effective mass of an electron in a quantizing magnetic field under the effect of a pressure-exerting electric field is shown to be consistent with the phenomenon of self-consistent deformation of the surface of helium under the effect of a localized electron. An analytical solution is given to the problem of the influence of self-consistent deformation of the surface of helium on the value of the cyclotron frequency of surface electrons in the presence of a strong magnetic field. It is demonstrated that for electrons localized on the surface of liquid helium the shift in the cyclotron resonance frequency has a twofold origin: 1) a dynamic shift resulting from the interaction of electrons with thermal vibrations of the helium's surface, and 2) a static shift resulting from self-consistent deformation of the surface of the helium under a localized electron exerting pressures on the free surface of helium, and the counter influence of this deformation on the electron's motion. The question is discussed of the relative role of both these shifts in the case of low density of surface electrons. Static renormalization of the cyclotron frequency of surface electrons plays the key role under conditions of slight heating of the electron system and fairly low temperatures. The shift in the cyclotron resonance frequency is of static origin if $T \ll \hbar\omega_H$, where ω_H is the cyclotron frequency, over the entire range of pressure-exerting fields. In an intermediate temperature range of $T \lesssim \hbar\omega_H$ the dynamic shift begins to compete with the static shift and even proves to be preferred. The concept of the characteristic density of surface electrons is introduced, which has a considerable influence on the amount of the static shift. At this density, electron-electron interaction exerts a considerable influence on the r.m.s. displacement of electrons from the position of equilibrium. The results of the theory presented describe correctly from a qualitative standpoint the experimental data available for the cyclotron resonance frequency shift for the conditions given here over a wide range of electron density and of the pressure-exerting field, but not without certain inconsistencies. The need for further study is stressed. References 15: 11 Russian, 4 Western.
[30-8831]

KINETICS OF THE DISINTEGRATION OF METASTABLE POLARIZED CRYSTALS

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 77 No 3([illegible]), Sep 79 pp 1093-1106 manuscript received 26 Mar 79

KAGAN, Yu., SMIRNOV, B. M. and SHLYAPNIKOV, G. V., Institute of Atomic Energy imeni I. V. Kurchatov

[Abstract] Metastable polarized crystals are crystals made up of atoms with parallel electron spins. A demonstration is given of the fact that the disintegration of a crystal of this type is associated chiefly with the origin of distinctive spin waves called magnons, which carry negative energy. A theoretical description is given of the key channels for the disintegration of metastable polarized crystals, and it is demonstrated that these channels can be suppressed by employing an external magnetic field opposite to the direction of polarization of electron magnetic moments. Dipole-dipole interaction between electron spins results in the decay of the polarized state into one magnon and two phonons, and a second-order process caused by simultaneous hyperfine interaction and magnon-phonon interaction of an exchange nature results in the decay of the polarized state into one magnon and one phonon. Disintegration channels of this type are not suppressed by a magnetic field. These two channels are discussed individually. Discussed in detail are local spin flip, spin waves in metastable polarized crystals, and the decay of a crystal by means of the excitation of spin waves, in terms of single-magnon and two-magnon excitation and decay via the excitation of magnons and phonons. The application of an external magnetic field as described above makes it possible to suppress generally single-magnon and two-magnon decay without the excitation of phonons or with the excitation of a single phonon on account of dipole-dipole interaction. In the case of polarized crystals of alkali atoms the first of the decay channels mentioned which cannot be suppressed by a magnetic field results in a probability of decay per particle of approximately 10^{-3} to 10^{-4} s^{-1}, which represents a fairly long lifetime. The second channel represents a relatively faster process, with a probability of decay in the range of approximately 10^{-1} to 10^{-3} s^{-1}. The extent of this probability varies substantially from element to element and from isotope to isotope. This decay channel can also be suppressed with the simultaneous polarization of nuclear spins. Figures 1; references 4: 2 Russian, 2 Western.
[31-8831]

USSR UDC 533.27

INVESTIGATION OF THE INTERACTION OF A HYPERSONIC AIRFLOW WITH A CARBON DIOXIDE AEROSOL

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manuscript received 2 Jan 79

ALFEROV, V. I., BIRYUKOV, A. S., BOZHKOVA, Ye. A., DMITRIYEV, L. M.,
MARCHENKO, V. M. and PROKHOROV, A. M., Physics Institute imeni P. N.
Lebedev, Academy of Sciences USSR, Moscow

[Abstract] In this paper an examination is made of gasdynamic processes that take place when heterogeneous flows interact with consideration of phase transitions, and it is shown that emission is amplified when a CO_2 aerosol is mixed with a hypersonic airflow. Analysis shows that the vaporizing aerosol mixes with the vibrationally excited gas in times that are shorter than the relaxation time of the upper lasing level. For flat flow geometry with symmetric input of the aerosol, the transverse size of the active medium may reach 20 cm or more when the height of the critical cross section of the hypersonic nozzle is of the order of 1 mm. Conditions are found under which there are no gasdynamic perturbations in the mixing zone and the active medium is optically homogeneous. A CO_2 aerosol generator is developed with a distribution function of solid particles by sizes that is close to optimum. Experiments on flow interaction are done on a facility with a conical hypersonic nozzle for air with perpendicular aerosol inlet. General agreement is observed between the experimental results and the theoretical predictions. Amplification of CO_2 laser radiation close to the calculated value is observed in the region of mixing of the excited air with the CO_2 aerosol. Figures 6, references 9: 6 Russian, 3 Western.
[24-6610]

USSR UDC 533.6+535.21

EXPANSION OF THE PLASMA LAYER NEAR A LASER-IRRADIATED OBSTACLE IN HIGH-DENSITY GASES

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 247, No 6, 1979 pp 1368-1371
manuscript received 10 May 1979

NEMCHINOV, I. V., PETRUKHIN, A. I., PLESHANOV, Yu. Ye. and RYBAKOV, V. A., Institute of Physics of the Earth imeni O. Yu. Shmidt, Academy of Sciences USSR, Moscow

[Abstract] Previous research has dealt with the onset and evolution of a plasma cloud close to an obstable surrounded by high-density gases under the action of neodynium laser emission with duration of $\tau = 1$ ms and spot diameter of $d = 1$ mm. Under such conditions, because of lateral spreading of the plasma, the pressure in it is close to the initial pressure of the gas medium, and the rate of expansion of the plasma boundaries is only a few meters per second. As τ decreases and d increases, the process of plasma development will take place under different conditions. In this paper, the authors report on experiments done with a neodymium laser with energy $E = 80$ J emitting a smooth bell-shaped pulse with duration of $\tau_{1/2} = 0.5\ \mu$s incident on a flat obstable. The laser spot had sharp edges, and within the limits of its diameter of $d = 8$ mm the uniformity of irradiation was no worse than 10-15%. Any time pulsations in the density of the laser flux were shorter than 1-3 ns. The obstacle was placed in a chamber filled with high-density gases. It was found that high density retards dispersal of the laser plasma. The hot gas behind the plasma front expands like a flat layer, generating a plane shock wave in the gas. Curves are given showing the time dependence of brightness temperature for variation emitted by the plasma in opposition to the laser beam, and also for pressure on the obstacle, and for the height of the shock wave and plasma front. Two pressure peaks are observed on these time curves: the first is associated with completion of the mode of vaporization and onset of the plasma that shields the obstacle from the direct action of laser exposure. This peak corresponds to sharply rising brightness temperature. The second peak is associated with a transition to the mode of "expulsion" in which the mechanical efficiency is rather high despite shielding because considerable amounts of dense gas surrounding the target are put into motion. The use of different gases produces results that are similar qualitatively though differing in magnitude. Turbulization or perturbation of the plasma front, at least far from the light detonation threshold, does not have a strong effect on parameters as calculated by the laminar theory. The authors thank Ye. A. Berchanko, A. P. Sobolev and B. T. Fedushin for their report on the hypothesis of turbulent light combustion before publication. Figures 3, references 8 Russian.
[20-6610]

USSR UDC 621.375.826

THEORETICAL STUDY OF THE DYNAMICS OF STIMULATED EMISSION AND THE CHARACTERISTICS OF A PULSED CO LASER WITH SELECTION OF LINES SUITABLE FOR LASER ENRICHMENT OF ISOTOPES

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KONEV, Yu. B., KOCHETOV, I. V. and PEVGOV, V. G., Institute of High Temperatures, Academy of Sciences USSR, Moscow

[Abstract] The practical feasibility of a CO laser for isotope enrichment is limited by the efficiency, power and duration of the emission pulse. Lasing with line selection must be used in photochemistry, and pulses with a duration of several microseconds are necessary for many practical applications. A theoretical study is done on the characteristics of a CO laser pumped with pulses of about 1 μs duration, and with selection of lines that are suitable for laser enrichment of isotopes, such as $P_9(16)$, $P_9(19)$, $P_{10}(9)$ and $P_{10}(12)$. A numerical solution is found for the system of kinetic equations for populations of levels of molecules of carbon monoxide, and unsteady equations of balance for emission intensities on vibrational-rotational transitions of carbon monoxide, as well as the equation for gas temperature. It was found that when a CO laser is pumped by short pulses, with selection of lines in the bands $P_9(J)$ and $P_{10}(J)$, emission pulses can be obtained with a duration of several microseconds, but the gas temperature must be low, about 50-80 K, and an energy density of 0.05-0.1 J/cm^3 is necessary at a pressure of 100 mm Hg and a temperature of 80 K (mixture CO:Ar = 1:10). The efficiency with consideration of losses in line selection should not exceed a few percent. Figures 6, references 7: 4 Russian, 3 Western.
[24-6610]

USSR UDC 621.378.325

STATISTICAL PROPERTIES AND STABILIZATION OF A PICOSECOND LASER ON PHOSPHATE GLASS WITH RECURRENCE RATE OF 2 Hz

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manuscript received 9 Oct 78

DIKCHYUS, G., ZHILINSKAS, E., PISKARSKAS, A. and SIRUKAYTIS, V., Vil'nyus State University imeni V. Kapuskas

[Abstract] Research is done to develop a picosecond phosphate glass laser with passive mode locking that compines high reproducibility and stability of emission characteristics with a recurrence rate between 0.5 and 2 Hz. Particular attention is given to development of a picosecond measurement complex for measuring the statistical parameters of the laser.

The measuring equipment is based on a nonlinear-optics correlator of amplitude analyzers with direct computer input. Reproducibility of ultrashort pulse lasing of better than 0.95 is achieved by optimizing saturation of gain and enhancement of transmission properties of the two-component lasing medium. The pumping energy of the laser is reduced to 260 J, and the coefficient of energy variation of the picosecond pulses is reduced to 0.08. The average duration of pulses in a train is 8.5 ps. Pulses with duration of 2.6 ps were obtained by induced Raman scattering. The duration of an isolated pulse selected from the beginning of a lasing train is 6.2 ps. The spectral Q (the product of the width of the spectrum multiplied by the duration of a pulse selected from the beginning of a train) is 0.5 in this situation, which shows absence of phase modulation. The high stability of the laser makes it suitable for using the second harmonic to pump a parametric light emitter on a crystal of α-HIO . The arrangement gives an energy conversion of up to 10% with spectral Q of 0.7. The authors thank S. A. Akhmanov for support and constructive criticism. Figures 7, references 20: 13 Russian, 7 Western.
[24-6610]

USSR UDC 621.373.826.038.823

THEORY OF A CHEMICAL LASER ON ELECTRONIC PHOTOTRANSITIONS WITH THERMAL INITIATION BEHIND A SHOCK WAVE FRONT

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IZMAYLOV, I. A., KOCHELAP, V. A., KUKIBNYY, Yu. A. (deceased) and PEKAR, S. I., Institute of Semiconductors, Academy of Sciences UkrSSR, Kiev

[Abstract] The authors work out a theory of steady-state lasers that operate at a gas pressure of 1 atmosphere or more where the time for a thermal chemical reaction is no more than 1 μs, and the reaction zone in the stream is no larger than 1 mm. The reaction must not have time to take place over a comparatively long time of mixing and feeding the mixture to the cavity. To accomplish this, the temperature of the mixture in the gas supply line must be so low that no reaction will take place. The reaction must be stimulated inside the optical cavity itself in times of much less than 1 μs. This can be done by a sharp increase in the gas temperature (by thousands of degrees in 0.1 ns) at the shock wave front set up inside the resonator. Only reactions of radiative recombination of atoms and radicals are considered here. Radicals react rapidly even at low temperatures, and therefore cannot be present in the supply line. These radicals must be produced rapidly and in large quantities inside the optical cavity, for example by thermal dissociation of stable molecules behind the shock wave front. A theory of shock waves and one-dimensional steady-state gasdynamic flow is developed with consideration of the kinetics of chemical reactions in the gas. The inverse population behind the

shock wave front is calculated for the case of reactions of photorecombination. It is proved that a waveguide arises that localizes the working mode of the laser in the inversion zone. The amplification factor of light α on the waveguide modes is calculated. The light-stimulated chemical reaction that changes the spatial dependences of density, temperature, flowrate and reagent concentrations is taken into consideration in the lasing mode in gasdynamic and chemical kinetics. The specific luminous power taken off from the flow is determined as a function of luminous losses. An examination is made of a number of specific gas mixtures, and the three most promising ones are selected for use in lasers: NO_2Cl-Ar, O_3-Ar and O_3-CO. It is shown that for these mixtures inversion arises over a wide range of wavelengths and that the conditions of waveguide arisal are compatible with the condition of formation of inversion. For these mixtures, the amplification factor of light is about 10^{-3} cm^{-1}, and the power is about 100 kW per cm^2 of the gas flow. Figures 6, references 32: 20 Russian, 12 Western.
[24-6610]

USSR

UDC 621.373.8

ANISOTROPY OF INELASTIC SCATTERING AND SELECTIVE DIFFUSION OF COMPONENTS IN A GAS MIXTURE UNDER THE ACTION OF LASER EMISSION

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manuscript received 18 Oct 78

KALYAZIN, A. L. and SAZONOV, V. N., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR, Moscow

[Abstract] Recent experiments have shown nonthermal and selective action of laser emission on gases. Selectivity with respect to isotopic composition has been demonstrated in radiative dissociation of monatomic molecules. The emission intensity in these experiments was 10^7-10^9 W/cm^2. Selectivity with respect to chemical composition has been studied, and nonthermal dissociation of one of the components has been observed in the collisional mode. In these experiments, the intensity of resonant laser emission was relatively low (16-400 W/cm^2). In this study the authors show that selective diffusion (i. e. spatial separation of the components of the mixture in the collisional mode that takes place only with laser excitation of one of the components of the mixture) is possible at even lower emission intensities. A theoretical analysis is made of selective diffusion in a mixture that consists of light particles (molecules or atoms) that are resonantly stimulated by laser emission, and heavy particles that do not interact with radiation. In particular, it is shown that the concentration of light particles can be noticeably changed to a distance of 30 cm by infrared laser emission with intensity of only 5 W/cm^2 in a mixture with pressure of 1 mm Hg at a temperature of 500 K. This effect

is unrelated to either luminous pressure or thermal diffusion. The authors thank G. A. Askar'yan, N. V. Karlov, Yu. N. Petrov, A. N. Orlov and other participants in A. M. Prokhorov's seminar for discussing the work. Figures 2, references 14: 6 Russian, 8 Western.
[24-6610]

USSR UDC 621.373.826.038

KINETICS OF XeF EXCIMER GAS-DISCHARGE LASER

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 6, No 8, Aug 79 pp 1639-1647 manuscript received 20 Oct 78

MKRTCHYAN, M. M. and PLATONENKO, V. T., Moscow State University imeni M. V. Lomonosov

[Abstract] Previous theoretical research on the kinetics of excimer gas discharge lasers has been mainly qualitative. In particular, as yet no kinetic model has been proposed that accounts for the most complete set of possible processes and that explains the experimentally observed dependences of emission output energy on the total pressure of the mixture and the percent concentration of its individual components. The authors attempt to solve this problem on the basis of a proposed kinetic model for a laser based on a mixture of He-X-NF_3 (X = Ar, Kr, Xe) excited in a short electric discharge. The proposed model with the use of relations for the kinetic coefficients as functions of E/p and p gives a basically correct description of the dynamics of the active medium in such a laser and can be used to predict the optimum values of experimentally important parameters such as the pressure of the mixture, pulse duration and so on. The model also enables evaluation of the concentrations of excited excimers attainable under pulse discharge conditions. The kinetic scheme considered in this paper is applicable to He-Kr-NF_3 and He-Ar-NF_3. Figures 4, references 22: 3 Russian, 19 Western.
[24-6610]

USSR UDC 621.373.826.038.824

EFFECT OF DYE LASER LINEWIDTH ON THE DEGREE OF CONVERSION OF EMISSION TO DIFFERENCE-FREQUENCY LASING

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manuscript received 1 Nov 78

ROSENFELD, A., KONIG, R. and TAM, N. H., Central Institute of Optics and Spectroscopy, Academy of Sciences of East Germany, Berlin

[Article translated from English by A. S. Semenov]

[Abstract] The paper gives the results of an investigation of the influence that the linewidth of dye laser emission has on the degree of conversion of emission power to difference-frequency lasing. Of particular interest is the feasibility of difference-frequency lasing over a wide frequency band. The analysis is done for pumping emission on various wavelengths. To get maximum efficiency it is necessary to reduce the dye laser linewidth. The longer the difference-frequency lasing wave, the narrower the bandwidth should be. Experiments are done in which dye laser radiation on 590 nm with linewidth varying from 0.15 to 6.5 nm is converted to difference-frequency lasing with pumping by a nitrogen laser and KDP crystal 3 cm long. The maximum degree of conversion is $3 \cdot 10^{-4}$. The authors thank Professor Hertz for furnishing the dye laser, Doctor S. Mori for constructive criticism, and Doctor Beck-Ross for furnishing a thin-layer Fabry-Perto interferometer. Figures 5, references 9: 1 Russian, 8 Western.
[24-6610]

USSR UDC 621.375.826

ON THE ULTIMATE LENGTH OF LASERS USING COMPLEX ORGANIC COMPOUNDS WHEN LASING IS REABSORBED BY UNEXCITED AND EXCITED SINGLET MOLECULES

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manuscript received 20 Nov 78

STOYLOV, Yu. Yu., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR, Moscow

[Abstract] An examination is made of the mechanism of limitation of stimulated emission power in lasers based on complex organic compounds with consideration of the influence of reabsorption of stimulated emission by unexcited and excited singlet molecules. It is shown that reabsorption leads to limitation of the laser emission power. The efficiencies of stimulated emission of lasers and amplifiers are compared. Formulas

are derived for evaluating the ultimate length of amplifiers and lasers. Dimensionless parameters are found that define the feasibility of scaling laser systems based on complex organic molecules. Examples are given of calculation of the emission parameters of lasers based on POPOP vapor and on a solution of rhodamine 6G. The author thanks K. K. Trusov for constructive criticism. Figures 4, references 9: 4 Russian, 5 Western.
[24-6610]

USSR UDC 621.375.9:535

INCREASING THE EMISSION BRIGHTNESS OF A POWERFUL Nd^{3+} PHOSPHATE GLASS LASER BY SPATIAL FILTERING OF THE BEAM IN AN AMPLIFICATION CHANNEL

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manuscript received 9 Nov 78

ALEKSEYEV, V. N., STARIKOV, A. D., CHARUKHCHEV, A. V. and CHERNOV, V. N.

[Abstract] An experimental investigation was made of the influence that small-scale self focusing has on the output brightness of the beam of the amplifier channel of neodymium glass lasers. Sources of regular perturbations of the spatial profile of the amplified beam were eliminated by using an apodizing aperture and an optical relay. Spatial filtering of the amplified beam was used to suppress irregular perturbations. It is shown that the brightness of the output beam can be considerably heightened by appropriate selection of the parameters of the vacuum spatial filter. A beam 40 mm in diameter is produced with peak intensity of 2.4 GW/cm^2; small-scale focusing did not cause any noticeable energy losses in an angle fo 0.25 mrad. The authors discuss the feasibility of using criteria of evaluation of the influence that small-scale self focusing has on the brightness of the amplified beam in developing amplification channels with periodic spatial filtration. The authors thank A. A. Mak for support of the work and constructive criticism, V. A. Teslenko for assistance in analysis of the results and manufacture of the apodizing apertures, and N. M. Vasilenko for assistance with the computer calculations. Figures 5, references 12: 7 Russian, 5 Western.
[24-6610]

USSR UDC 621.373.826.038.823

NONRECIPROCAL EFFECTS IN A RING LASER WHEN A TRANSVERSE MAGNETIC FIELD IS APPLIED TO AN ACTIVE MEDIUM

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ANDRONOVA, I. A., KUVATOVE, Ye. A. and MAMAYEV, Yu. A., Institute of Applied Physics, Academy of Sciences USSR, Gor'kiy

[Abstract] Nonreciprocal amplitude and frequency effects are calculated in a helium-neon ring laser when a transverse magnetic field is applied to the active medium. This is a problem of interest for physics and laser gyroscopy in evaluating the corrections to laser gyroscope readings that are associated with transverse magnetic fields. In addition, it is shown that the study of such nonreciprocal effects may be useful in nonlinear laser spectroscopy for measuring the constants of relaxation of working levels. An examination is made of the case of polarizations of opposed waves that are close to linear. It is shown that these effects are a manifestation of nonlinear polarization nonreciprocal properties that arise in the active medium when the transverse magnetic field is applied. The effects depend on the square of the magnetic field and its orientation relative to the electric field of the wave. Numerical estimates are made of possible errors of laser gyroscopes that are associated with transverse magnetic fields. The authors thank I. L. Bershteyn for a number of useful comments in examination of the manuscript. Figures 2, references 11: 5 Russian, 6 Western.
[24-6610]

USSR UDC 621.373.8.537.533

OPTIMIZATION OF THE PARAMETERS OF ELECTRON BEAMS AND SELECTION OF FOIL IN AN ELECTRON-BEAM-CONTROLLED LASER

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DUTOV, A. I., MINAYEV, S. V. and NIKOLAYEV, V. B.

[Abstract] An investigation was made of the transmission of electrons with energy of 100-250 keV through a foil-gas-anode system in an electron-beam-controlled laser, and an estimate was made of the homogeneity of ionization of the working substance over the height of the discharge gap. An examination is made of the influence that the beam parameters, composition of the active medium and the electric field in a semi-self-maintained discharge, as well as the design peculiarities of the laser have on both the homogeneity of ionization of the discharge gap and the uniformity of

the electric field in the gap. The authors discuss problems of selecting beam energy and the structural elements of the laser when light foils are used. In calculating the distribution of ionization losses and electric field with respect to the height of the discharge gap, the energy of the monochromatic electron beam incident on the foil was varied as well as the average amplitude of the electric field applied between the cathode grid and the anode. An investigation was also made of the influence that the materials of the foil and anode, as well as the foil thickness have on the distributions of ionization losses and electric field. The results of the calculations can be used in drawing some conclusions relative to optimizing the parameters of the electron beams and foils, and also in determining requirements for design of electron-beam-controlled lasers. It is shown that using light foils in combination with reduced electron beam energy can increase the concentration of secondary electrons in the plasma, reduce the discharge cross section (by reducing the scattering angles in the foil) and also lighten biological shielding and simplify the installation. Light foils also lighten biological shielding and simplify the installations. Light foils also have low losses with respect to the energy and number of particles, which enables them to transmit a greater average power of the electron flux. For operation under optimum conditions it should also be borne in mind that if the beam energy changes by only 10-20 keV during a pulse, this may lead to redistribution of ionization losses over the discharge gap and to amplification of the electric field in the cathode or anode region. The authors thank A. A. Mak for useful discussion, and Yu. A. Anan'yev and N. N. Rozanov for continued interest and assistance in the work. Figures 7, references 24: 10 Russian, 14 Western. [24-6610]

USSR UDC 621.373.826.038.823

LASING MODES AND CHARACTERISTICS OF EMISSION OF A PHOTODISSOCIATION IODINE RING LASER

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manuscript received 27 Nov 78

KURZENKOV, V. N.

[Abstract] Theoretical and experimental studies of the modes of stimulated emission of ring lasers show that an important role in the mechanism of lasing is played by the parameters and form of the amplification loop as determined by the type of active medium, the amplidude of pumping and the level of reverse signals. Previous research has not dealt with the properties of the photodissociation ring laser using atomic iodine, which is of particular interest because of the possibility for wide variation of its parameters. In this paper an experimental study is done on a number of the characteristics of such a laser, and the energy conditions and

properties of the output emission are studies. The experiments were done in a four-mirror cavity arrangement with measurement of energy, space-time and polarization characteristics. It is shown that the principal role in formation of the directions of stimulated emission are played by weak reverse signals, which in the absence of additional mirrors may arise as a consequence of parasitic reflections or scattering. Under conditions of flash-tube pumping the measurements show that dynamic waves of inhomogeneities influence the lasing threshold. This effect shows up in the space-time structure of the near-field pattern. It is shown that polarization of the output emission is linear in the absence of external magnetic fields. It is also shown that a ring laser can be used for studying amplification systems that suppresses self-excitation of the amplifier on resonator mirrors. The author thanks N. N. Rozanov for discussing the results, and also I. M. Belousova for a number of recommendations of practical value. Figures 5, references 10: 9 Russian, 1 Western.
[24-6610]

USSR UDC 621.375.826:534.8

A NEODYMIUM GLASS LASER WITH RADIATION INTENSITY CONTROLLED BY ULTRASOUND

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 6, No 8, Aug 79 pp 1740-1745
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[Abstract] The paper gives the results of an experimental study of the principal patterns that govern the process of neodymium glass laser modulation when longitudinal oscillations of the active element and the mirror are excited, and an examination is made of the mechanism of ultrasonic modulation of solid-state laser radiation. The experiments are done with ultrasonic excitation of the active element or one of the cavity mirrors in the 20-200 kHz range. The intensity is modulated with double the frequency of the stimulated ultrasonic oscillations with a simultaneous increase in the average peak intensity by a factor of 2-3. The total emission energy in a pulse remains unchanged. An investigation is made of the patterns of modulation as a function of the amplitude and frequency of ultrasound over a wide pumping range, and it is shown that these patterns do not depend on the type of active medium of the laser. An examination is made of the mechanism of ultrasonic modulation of solid-state laser emission. Figures 4, references 7 Russian.
[24-6610]

USSR UDC 621.378.325

INVESTIGATION OF THE PROPERTIES OF A LASER WITH UNSTABLE CAVITY AND ADDITIONAL FEEDBACK

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ANAN'YEV, Yu. A., GORYACHKIN, D. A., SVENTSITSKAYA, N. A. and PETROVA, I. M.

[Abstract] If an additional element such as a mirror or semiconductor plate is introduced into a laser with unstable cavity, a convergent wave can be produced that will enhance emission density in the paraxial zone and lower the emission threshold. Both of these effects may be useful in various practical applications. The authors investigate the case of an additional mirror that covers only part of the cross section of the cavity, which precludes the possibility of existence of closed trajectories within the framework of the geometric approximation. The experiments were done with a neodymium glass laser (active element 45 mm in diameter and 600 mm long) operating in the mode of free lasing. To simulate the case of low-gain media, only 200 mm of the active element was pumped. Under these conditions the optimum magnification M of an ordinary telescopic cavity (without the additional reflector) is 1.2-1.3. The use of such a cavity with M = 1.26 gives an output energy of about 30 J and angular divergence of radiation (at half amplitude) of about 1.5'. The emission threshold can scarcely be reached when M = 2 in an ordinary cavity. With an added reflector the output energy was even a little greater than 30 J with magnification M = 3.8. Only with a 100% reflector and M = 8.3 did the output drop to 12 J. The angular divergence was never less than 2', and reached 4.5' with M = 2 in the case of a 100% reflector. Thus it does not seem feasible to achieve satisfactory beam convergence by this technique. Figures 2, references 7: 6 Russian, 1 Western.
[24-6610]

USSR UDC 621.373.826

SOME RESULTS OF EXPERIMENTS ON A GASDYNAMIC CO_2 LASER

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GORYACHEV, S. B., TIKHONOV, B. A. and SHARKOV, V. F., Institute of Atomic Energy imeni I. V. Kurchatov, Moscow

[Abstract] The paper gives the results of preliminary experiments on a CO_2 gasdynamic laser with heating of the working mixture of N_2-CO_2-He in a plasmotron. A specific energy output of 20 J/g and efficiency of about 1.2% are experimentally achieved in the cw mode at a stagnation temperature of 1700 ± 100 K and parameter $p_* h^*$ of the order of 0.5 atm·cm or less when the total flowrate of the gas mixture is about 0.5 kg/s. Figure 1, references 4 Russian.
[24-6610]

USSR UDC 535.241.13

SPACE-TIME LIGHT MODULATOR FOR CONTROLLING LASER RADIATION

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 6, No 8, Aug 79 pp 1780-1783
manuscript received 27 Nov 78, after revision 23 Mar 79

KUZOVKOVA, T. A. and NILOV, Ye. V.

[Abstract] The paper describes a principle for using an electro-optical crystal of KDP type to set up a nonuniform electric field so that these electro-optical crystals can be used in combination with polarizers for space-time light modulation with alternate action as a high-speed shutter and as a diaphragm with a soft edge. An experimental check has shown that the technique used for calculating electric fields in such modulators, establishing the reciprocal relation between design parameters and the distribution of light transmission with respect to the cross section of the crystal gives an error of no more than 10%. Figures 2, references 5: 4 Russian, 1 Western.
[24-6610]

USSR UDC 621.375.826:535.37

IMPROVING THE EFFICIENCY OF NEDYMIUM LASERS BY CONVERTING PUMPING EMISSION IN A FLUORESCING LIQUID

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 6, No 8, Aug 79 pp 1795-1798 manuscript received 7 Mar 79

VODOP'YANOV, K. L., IL'ICHEV, N. N., MALYUTIN, A. A., MATYUSHIN, G. A. and PODGAYETSKIY, V. M., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR, Moscow

[Abstract] An investigation is made of the influence that conversion of the pumping radiation spectrum by a fluorescing spectrum (a rhodamine 6G solution in ethanol) has on the emission energy of a neodymium YAG laser. An analysis is made of the way that the conversion efficiency depends on the concentration of fluorescing liquid and the type of active medium. The output energy of the laser in the free emission mode is doubled, the differential energy is increased by 50-130% and the lasing threshold is reduced by 10-20%. The experimentally measured values are compared with the results of calculation. Figures 3, references 11: 8 Russian, 3 Western. [24-6610]

USSR UDC 621.373.826

GENERATION OF THE THIRD HARMONIC OF RADIATION OF A RUBY LASER IN THALLIUM VAPOR

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 6, No 8, Aug 79 pp 1801-1804 manuscript received 17 Jan 79

KIYASHKO, V. Ya. and TIMOFEYEV, V. P., Institute of Physics imeni L. V. Kiremenskiy, Siberian Department, Academy of Sciences USSR, Krasnoyarsk

[Abstract] One of the ways to improve the efficiency of laser conversion in parametric processes is by focusing into the center of a nonlinear medium, which increases pumping intensity and improves the conditions of phase matching of interacting waves. In this paper an investigation is made of the influence that the degree of focusing has on generation of the third harmonic of a ruby laser in thallium vapor. It is experimentally shown that as the focal length of the lens used for focusing decreases there is an increase in the maximum lasing signal, a shift into the high-temperature region and narrowing of the lasing curve. Figures 3, references 3: 2 Russian, 1 Western. [24-6610]

USSR UDC 621.375.826:539.196.5

ON THE EFFICIENCY OF A SELECTIVE CO LASER

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manuscript received 17 Jan 79

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USSR, Moscow

[Abstract] A CO laser emits simultaneously on several vibrational-rotational bands from 5 to 8 μm. A selective cavity is used to isolate emission on a single frequency. Previous research has covered the efficiency of a CO laser with selective cavity. In this paper, more complete consideration is taken of the specifics of selective lasing. The limiting factor for efficiency is molecular transmission of quanta into the upper part of the vibrational spectrum with bypass of the lasing transition. The efficiency of the lasing transition is found as well as the law of gain saturation. Analysis is based on flow of excitation quanta in the vibrational spectrum corresponding to localization of pumping in the lower part of the spectrum, and quenching in the upper part. Figure 1, references 5: 4 Russian, 1 Western.
[24-6610]

USSR UDC 621.373.826+536.46

INFLUENCE THAT PARAMETERS OF A HYDROGEN FLUORIDE MIXTURE HAVE ON THE VELOCITY OF FLAME PROPAGATION

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manuscript received 5 Feb 79

BASHKIN, A. S., KOLCHIN, Yu. A., ORAYEVSKIY, A. N., PSHEZHETSKIY, S. Ya., CHEBOTAREV, N. F., YURYSHEV, N. N. and VAGIN, N. P., Physics Institute
imeni P. N. Lebedev, Academy of Sciences USSR, Moscow

[Abstract] The rate of flame propagation in hydrogen fluoride mixtures is experimentally studied at atmospheric pressure. It is shown that if the mixture is diluted with a diatomic gas such as nitrogen instead of monatomic gases, or if the polyatomic gas SF_6 is added without any change in energy accumulation, there will be a sharp reduction in burning rate and an increase in the threshold pressure of fluorine where burning changes to detonation in the investigated conditions. The results show the feasibility of developing a pulsed periodic laser with high energy characteristics. Figures 2, references 4: 2 Russian, 2 Western.
[24-6610]

USSR UDC 621.373.8+621.375.826

CHARACTERISTICS OF PULSED LASING ON TRANSITIONS IN THE BARIUM ATOM

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manuscript received 16 Jan 79

ISAYEV, A. A., LEMMERMAN, G. Yu., MARKOVA, S. V. and PETRASH, G. G., Physics Institute imeni P. N. Levedev, Academy of Sciences USSR, Moscow

[Abstract] The paper presents the results of a study of the characteristics of lasing on atomic lines of barium with wavelengths of 1.5 and 1.13 μm. Lasing in barium vapor was studied in a conrundum discharge tube with inside diameter of 25 mm and length of the heated section of 85 cm. Water-cooled electrodes were used. Quartz plates with transmission that determined the investigated spectral region were cemented on the ends, cut at an angle of 4°. The density of the barium vapor was determined by wall temperature. Emission was stimulated by discharging a working capacitor through a pulsed thyratron. Excitation pulse duration was 200 ns with rise time of about 30 ns, and recurrence rates of 8 and 13.3 kHz. The average emission power is studied as a function of the buffer gas pressure and the supply power. The spectral and time characteristics were studied. A maximum average lasing power of 12.5 W was achieved at an efficiency of 0.5%. Maximum efficiency of the barium vapor laser is 0.72%. Figures 4, references 7: 5 Russian, 2 Western.
[28-6610]

USSR UDC 621.373.826.038.823

INVESTIGATION OF THE CHARACTERISTICS OF A FAST-FLOW CW CO_2 LASER STIMULATED BY A SELF-MAINTAINED DC DISCHARGE

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manuscript received 22 Jan 79

BASIYEV, I. G., BLOKHIN, V. I., YEPISHOV, V. A., KUZ'MIN, V. N., MYSLIN, V. A., PASHKIN, S. V. and SHULAKOV, V. N., Institute of Atomic Energy imeni I. V. Kurchatov, Moscow

[Abstract] Experiments are done to determine the efficiency of a laser facility with rapid flow of carbon dioxide at elevated pressure. The accumulator of vibrational energy is atmospheric nitrogen. The water vapor in the air quenches the lower laser level of the CO_2 molecule and makes helium unnecessary. The vibrational levels of nitrogen are stimulated in a discharge chamber, and the carbon dioxide is added to the mixture downstream from the discharge chamber. This arrangement enables operation at high pressures of the working mixture. The airflow in the

discharge chamber was set by calibrated nozzles. Air temperature at the inlet was 20°C, and relative humidity was 60-80%. The anode in the discharge zone was a copper plate, and the cathode was made up of small steel rods distributed opposite the plate, each rod being connected to a power supply through a ballast decoupling resistor. As a result of optimization experiments, a laser was developed with CO_2 pressure of 100 mm Hg, flowrate of about 200 m/s, discharge chamber efficiency of about 0.7, and gain of 1%/cm. The authors thank Ye. P. Velikhov for initiating the work, and A. A. Vedenov for interest. Figures 5, references 9: 3 Russian, 6 Western. [28-6610]

USSR UDC 621.373.826.038.825

AN ELECTRON-BEAM ULTRAVIOLET SEMICONDUCTOR LASER

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 6, No 8, Sep 74 pp 2045-2046 manuscript received 27 Mar 79

KURBATOV, L. N., KOZINA, G. S., KOSTINSKAYA, T. A., RUDNEVSKIY, V. S., TKACHENKO, I. M., GEORGOBIANI, A. N. and GUTAN, V. B.

[Abstract] Experiments are done to develop a miniature laser emitter in the ultraviolet range. ZnS and ZnO crystals were stimulated by an electron beam with energy of the order of 115 keV. Current density was 60 A/cm^2. Multi-component targets were studied with transverse pumping. The targets were made by cementing single crystals to molybdenum bases with forced cooling. Laser pulses were triangular with duration at half-power of 3-5 ns at a recurrence rate of 12 Hz. Targets of ZnS produced stimulated emission only at 80 K, with power of 0.5-0.7kW. The ZnO targets emitted at both 80 and 300 K with maximum pulse power of 3-5 kW. The authors thank A. N. Lobachev, I. P. Kuz'mina and V. A. Kuznetsov for furnishing the single crystals. Figures 2, reference 1 Russian.
[28-6610]

INVESTIGATION OF THE ABSORPTION OF A MOLECULE OF SF_6 OVER A BROAD RANGE OF INTENSITY OF INFRARED LASER EMISSION

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 77 No 3(9), Sep 79 pp 816-828 manuscript received 5 Feb 79

KNYAZEV, I. N. and LOBKO, V. V., USSR Academy of Sciences Institute of Spectroscopy

[Abstract] The results are given of an investigation of the dependence of absorbed energy in SF_6 on the emission intensity of a CO_2 laser in the intensity range of 1 to 10^6 W/cm^2. The experiments were conducted

with a laser unit without continuous frequency tuning, at fixed frequencies of a CO_2 laser at the atmospheric pressure of the working mixture. With an intensity of approximately up to 10^4 W/cm^2, the results are interpreted by taking into account the weakly forbidden single-quantum transitions $\Delta R \neq 0$ and $\Delta n \neq 0$. Measurements were made of the absorption of the emission of a CO_2 laser in uncooled gas cells filled with SF_6, at a gas pressure of less than 0.4 torr for the purpose of excluding the influence of collisions. An electron-beam-controlled CO_2 laser was used, with a lasing pulse energy of 0.2 J maximum and a pulse duration of 150 ns with a laser mixture pressure of 1 atm. The laser's cavity consisted of a 100 lines/mm diffraction grating and a flat semitransparent mirror placed at a distance of 150 cm from one another. The spectrum width of the laser emission equaled approximately 0.008 cm^{-1}. A mixture of CO_2:N_2 = 1:2 was employed in the laser, and measurements were made at lasing lines P(14), P(18), P(22) and P(26) in the laser's 10.6 μm emission band. The absorption of SF_6 was measured at transitions in the R branch (the laser's P(14) line) and P branch (remaining laser lines) of the ν_3 band. The intensity range of 1 to $4 \cdot 10^6$ W/cm^2 was covered. The laser emission was directed at the absorbing cell and was then recorded by means of a cooled Ge:Au photodetector, whose minimum sensitivity equaled 10 W. Part of the laser emission was diverted at the inlet of the absorbing cell for the purpose of measuring the reference signal. The intensity of the emission at the cell's inlet was measured by means of sets of calibrated absorbing filters consisting of layers of a Teflon film 30 μm thick. Recordings were made of the signal at the outlet of evacuated cells and cells filled with gas while changing the intensity of the laser emission in the cells by means of the calibrated filters and comparing the measured and reference signals. With a known geometry for illumination of the cells, a determination was made of the total number of molecules in the absorbing volume of gas, the mean number of absorbed photons, and of a parameter, δ, close in the physical sense to the product of the many-quantum absorption cross section, σ, and the share of molecules, q, taking part in absorption. The results of studying the absorption of the emission of a CO_2 laser in the ν_3 band of SF_6 are presented graphically. The curves presented show the absence of sudden breaks in crossing the linear absorption saturation limit, and the formation of plateaus on the $\delta(I)$ curve with a laser emission intensity of up to 10 to 100 W/cm^2. In the low-intensity region the mean number of absorbed photons increases in proportion to the intensity, and the magnitude of δ is approximately constant, which is typical of linear absorption. Deviations from linear absorption begin to appear with a power density of 2 to 20 W/cm^2. An experimental determination is made of the nature of the transition from linear to many-quantum absorption in the intensity range studied. The behavior of absorption in the intermediate region of intensities of up to 10^3 to 10^2 W/cm^2 is explained satisfactorily in the quantitative sense by taking into account many-quantum and single-quantum weakly forbidden transitions $\Delta R \neq 0$ and $\Delta n \neq 00$. The experimental results are explained by taking into account transitions with a radiative transition cross section equaling only 0.005 times the corresponding value for allowed transitions.

With a higher emission intensity, absorption is explained by the formation of a sequence of secondary chains of many-quantum transitions and the intramolecular exchange of excitation energy between mode types. Figures 7; references 22: 6 Russian, 16 Western.
[31-8831]

USSR UDC 543.42

CERTAIN PROBLEMS OF THE INTERACTION OF LASER RADIATION WITH TITANIUM ALLOYS

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 31 No 4, 1979
pp 606-611 manuscript received 21 Nov 78

GUSARSKIY, V. V., KUZYAKOV, Yu. Ya., SEMENENKO, K. A. and TIMOFEYEVA, L. N.

[Abstract] The erosion of a number of Ti alloys and bimetals was investigated as a function of the parameters of the laser source as well as of the physical and mechanical properties of the specimens. Erosion here is construed as the size (diameter and depth) of the craters formed in the specimen by laser radiation used as a means of microanalysis of the chemical composition of the specimens. Erosion was measured with the aid of a special micrometer. While crater diameter varied significantly only at near-threshold pumping lamp voltages, crater depth increased in direct proportion to the increase in voltage. The extent of erosion was inversely proportional to the Brinell hardness of some but not all Ti-base alloys, which points to the complexity of the mechanisms of interaction of the laser beam with Ti-base alloys. Tests of various sampling procedures show that the most effective procedure consists in the collection of the sample with the aid of a carbon tube of 2-4 mm diameter, and dissolving the sample by immersion in 5 cc H_2SO_4 (1:1). Figures 3; references 3 Russian.
[52-1386]

Nuclear Physics

EXCHANGE INTERACTION BETWEEN AN ATOM AND A MULTIPLY CHARGED ION

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 77 No 3(9), Sep 79 pp 858-866 manuscript received 23 Feb 79

DUMAN, Ye. L. and **MEN'SHIKOV**, L. I., Institute of Atomic Energy imeni I. V. Kurchatov

[Abstract] Collision processes involving multiply charged ions determine key parameters of modern thermonuclear plants and heavy-ion accelerators. A description is given of a method which has been developed which makes it possible within the framework of a quasi-classical approach developed earlier (1965) to find an analytical expression for the energy of exchange interaction, $\Delta(R)$, between any atom and a multiply charged ion. The expression obtained within the framework of this method for the energy of exchange interaction is the first term of an expansion in terms of orders of triviality of $z^{1/2}/R$, where z is the charge of the ion and R is the internuclear distance. The test for the applicability of the results obtained is therefore $R \gg z^{1/2}$, an inequality which justifies the use of the quasi-classical method for finding the wave function of an electron in the subbarrier region. The energy of exchange interaction between an atom and a multiply charged ion is found with great distances between the nuclei of the colliding partners, i.e., $R > z^{1/2}$. The potential for exchange interaction, $\Delta(R)$, is expressed in terms of known parameters of the atom and multiply charged ion, i.e., the ion's charge, z, the binding energy for an electron in the atom, $\gamma^2/2$, the magnitude of the orbital moment and of the spin of an electron in the atom and ion, where the projection of the orbital moment onto the axis connecting the nuclei is equal to zero. The quasi-classical method developed here properly describes interaction both in the intermediate region of distances between interacting partners where $4z^{1/2} < R < 2z$ and at the asymptotic limit of $R > 2z$. It is shown that there are two ranges of distances between interacting partners in which $\Delta(R)$ behaves differently as a function of the change in internuclear distance, R. In the range in which $R \gg 2z$, the equation for exchange interaction is transformed into the expression for the asymptotic case. The results obtained are easily generalized for the case when with great distances between partners the energy of exchange interaction is caused by the subbarrier transition of one of the outer electrons of the atom to an unoccupied level of the multiply charged ion. Figures 1; references 25: 12 Russian, 13 Western.
[31-8831]

USSR UDC 621.373.826

SPECTRAL DETERMINATION OF PLASMA PARAMETERS WITH 0.5 s TIME RESOLUTION

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 31 No 4, 1979
pp 592-596 manuscript received 9 Oct 78

BAKEYEV, A. A., VASIL'YEV, L. A., NIKOLASHINA, L. I. and PROKOPENKO, N. V.

[Abstract] The findings of an investigation of the plasma torch generated by exposing spectrally pure aluminum to the radiation of a neodymium laser operatiog in the free-running mode are presented. High-speed photography of the plasma radiation spectra with 0.5 μs time resolution was employed. The mean density of the flux of laser radiation directed at a target of 8 mm diameter was $\sim 10^7$ W/cm^2. The wavelength range selected for analysis was 440-470 nm, since it contains lines of Al^+, Al^{2+} ions and nitrogen ions with known transition probabilities and secondary Stark effect constants. The resulting pattern of action of laser radiation is such that it generates a high-pressure zone in the target. The heated aluminum vapors expand at supersonic velocities and, at some distance from the target, they form a quasi-stationary compression shcck. The obtained spectrograms of the torch with 0.5 μs time resolution warrant the assumption that the supersonic motion of aluminum vapor generates a shock wave propagating through unperturbed air ahead of the aluminum vapor. The compression-shocked air becomes heated and begins to radiate upon passage of powerful spikes of laser radiation (lines of ionized nitrogen can be seen ahead of the aluminum vapor). Thus the abosrption of laser radiation in air may be promoted by its photoionization due to the radiation of the target's vapor. Figures 2; references 7 Russian.
[52-1386]

USSR UDC 535.212

SURFACE REDUCTION OF OXIDES AND THEIR COMPOSITIONS BY MEANS OF LASER RADIATION

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 31 No 4, 1979
pp 618-622 manuscript received 20 Jan 78

SKIBA, P. A. and NEPOKOYCHITSKIY, A. G.

[Abstract] Surface thermochemical reactions initiated by laser radiation, and in particular the reduction of metal oxides, are of major interest to various domains of technology. In this connection the possibility of broadening the range of such reduction was investigated on specimens of cupric and cuprous oxide, nickel oxide, ferric oxide, as well as the ferrite compositions M 400-NM, M 1000-NM, M 1500-NM, and M 2500 NM.

The specimens were placed in a chamber filled with alcohol or its vapor and then subjected to laser radiation. The course of the reduction process was traced as a function of the variation in conductivity of the specimens, as well as with the aid of x-ray diffraction patterns. It was found that reduction by means of laser pulses may occur in stages, from the higher to the lower oxide, e.g. from CuO to Cu_2O. As for the ferrites, these turned out to require special conditions. To assure firm bonding of the reduced metal film to the ferrite and to avert the cracking of specimens under laser radiation, they are heated to 100-200°C and reduced in alcohol vapor. The problem of the nonuniform depth distribution of the reduced metal coating, which complicates the welding, brazing, etc. of ferrites, can be solved by depositing on it a layer of another metal with technologically satisfactory adhesion, for example, by an electrolytic method. In general, the use of lasers to reduce metal oxides serves to obtain surface metal films of any geometry, and both pulsed and CW lasers can be used for this purpose. Figures 4; references 7: 6 Russian, 1 Western.
[52-1386]

USSR UDC 778.38

ON THE POSSIBILITY OF RECONSTRUCTING HOLOGRAMS WITHOUT A REFERENCE BEAM

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 31 No 4, 1979
pp 639-644 manuscript received 23 Nov 78

ABLEKOV, V. K., KOLYADIN, S. A. and FROLOV, A. V.

[Abstract] The possibility of reconstructing certain characteristics of the object-field distribution function from Fourier holograms lacking a reference beam is considered. On the basis of an analysis of the autocorrelation pattern of the picture it is shown that a priori information on the object can be obtained in the form of the field distribution function at the field boundary. Further, with the aid of optical filtration in the space frequency range, the first derivative of the field distribution function in the plane of the object can be reconstructed. This method for hologram reconstruction was used to obtain the true image of an object with diffuse scattering. A corresponding analysis of plane Fourier holograms lacking a reference beam is presented from the standpoint of the asymptotic representation of the Fourier integral in the space frequency range. Figures 4; references 4 Russian.
[52-1386]

NONSTATIONARY COHERENT EFFECTS IN THE PULSED EXCITATION OF HYPERFINE STRUCTURE TRANSITIONS IN OPTICALLY ORIENTED ATOMS

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian
Vol 77, No 2, Aug 79 pp 505-518 manuscript received 30 Dec 78

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[Abstract] In the simultaneous pulsed excitation of two neighboring hyperfine structure transitions in optically oriented atoms radio-frequency coherence is evidenced, associated with the origin of a transverse magnetization component. By analogy with ordinary magnetic resonance one would expect the manifestation of nonstationary coherent effects, such as nutation, free precession and spin echo. The results are given of an experimental and theoretical study of these nonstationary radio-frequency coherence signals in optically oriented atoms of cesium ^{133}Cs. Light pumped from a cesium tube in which an electrodeless high-frequency discharge was excited passed through an interference filter admitting only the D_1 line of cesium (wavelength of 8943 Å), and through a circular polarizer and fell on an absorbing cell filled with cesium vapors and an Ne buffer gas. The variation in absorption of the pumped light by the cell with magnetic resonance was recorded by a photodetector and the signal was amplified and registered on an oscillograph. The source of the SHF magnetic field used to induce hyperfine structure transitions in cesium atoms was a 10 GHz band microwave oscillator with a maximum output power of 500 MW. A rectangular horn antenna was oriented in relation to the H_0 field so that both $\pi(\Delta m_F = \pm 1)$ and $\sigma(\Delta m_F = 0)$ magnetic dipole hyperfine structure transitions could be excited. Coherence between Zeeman sublevels $F = 4$, $m_F = -4$ and $F = 4$, $m_F = -3$ of ^{133}Cs atoms was registered from the absorption of the transverse magnetization component, H_0, of the light beam from the cesium tube after passing through the above-mentioned filter and circular polarizer. For the purpose of observing radio-frequency coherence echo signals, artificial inhomogeneity of the magnetic field was created by means of opposing rings supplied from a d.c. source and supplied with a video pulse from a pulse generator for the purpose of inverting the magnetic field gradient. Multiple spin echo radio-frequency coherence signals were detected, excited by two succesive microwave pulses, as well as a radio-frequency coherence echo signal after a signal microwave pulse and subsequent inversion of the magnetic field gradient. A theoretical discussion is presented, of the effects observed, using an approximation of a three-level quantum system perturbed in a pulsed manner by two resonant variable magnetic fields. Multiple spin echo and complex nutation in radio-frequency coherence are discovered, which are coherent effects not observed previously. Theoretical expressions are derived for nonstationary coherence signals which have made it possible to explain the characteristic dependence of a nutation signal on the duration of the microwave pulse, and the manifestation of additional spin echo signals, as well as to determine the optimal conditions for the excitation of echo signals for the two methods of producing echo. Figures 8; references 19: 10 Russian, 9 Western.

[30-8831]

INERTIA OF THE PROCESS OF STIMULATED MANDELSTAM-BRILLOUIN SCATTERING AND NONTHRESHOLD REFLECTION OF SHORT PULSES WITH WAVE FRONT REVERSAL

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 77 No 2, Aug 79 pp 526-536 manuscript received 17 Jan 79

YEFIMKOV, V. F., ZUBAREV, I. G., KOTOV, A. V., MIRONOV, A. B., MIKHAYLOV, S.I., PASMANIK, G. A., SMIRNOV, M. G. and SHILOV, A. A., USSR Academy of Sciences Physics Institute imeni P. N. Lebedev

[Abstract] In an earlier study it was demonstrated that in steady-state Mandelstam-Brillouin stimulated scattering it is possible to accomplish nonthreshold reflection of the weak signal with reversal of its wave front in the field of a strong wave for which the stimulated scattering threshold has been exceeded and the conditions for wave front reversal have been fulfilled. Nonthreshold reflection takes place only in the steady-state case when the characteristic time scales for the alteration of pulses are sufficiently great in comparison with the relaxation time of hypersound; in this case the reflection coefficients of the strong and weak pumping components are the same. In Mandelstam-Brillouin stimulated scattering of a short light pulse non-steady-state effects begin to play an important role and result in a difference in reflection coefficients and alteration of the shape of Stokes pulses in comparison with individual pumping pulses. A theoretical and experimental study is made of these phenomena. Wave front reversal and nonthreshold reflection are produced by two methods: in a light pipe, and by focusing the radiation in the active medium by means of a lens. Employed as the master oscillator was a neodymium laser with diffraction divergence and pulse duration at half-height of approximately 50 ns. The strong pumping component was achieved by coupling out part of the radiation from one face of a thick glass plate in order to avoid interference, and feeding it to an amplifier. A square pulse of 10 ns duration was isolated from the remaining part of the beam by means of a coaxial Pockels cell triggered by means of a spark gap. This pulse was also coupled to the amplifier from the face of the glass plate and acted as the weak pumping component. The active media in focusing with a lens were liquid CCl_4 and gaseous SF_6 at a pressure of 20 atm, and with a light pipe, liquid CS_2 and gaseous methane at a pressure of 150 atm. In experiments with a light pipe, both waves were brought together on a phase plate and the image of the lit area was transmitted by means of a lens with a focal length of 20 cm to the input of the light pipe. A rectangular metal light pipe was placed in the cell with methane, and a round glass light pipe was used for CS_2. A 17 cm focal length lens was used to focus the radiation in the active medium in the second method. A recording was made of the distribution of radiation in the back-scattered waves, of the strong and weak pumping components, respectively, in the close-range and remote zones; of their energy; and also of the shape of pulses. It was found that there is considerable pulling of the back-scattered pulse when its duration is shorter than or comparable with the relaxation time of hypersound. Under these

conditions there also takes place a reduction in the reflection coefficient of the weak pumping component as compared with that of the strong component. A method is suggested and modeled for producing fairly short pulses with wave front reversal under nonthreshold conditions. Pulses of this sort are required for many applications, for creating and studying laser plasmas, in particular. It is demonstrated that nonthreshold reflection with Mandelstam-Brillouin stimulated scattering in media with a short lifetime of acoustic phonons, CCl_4, for example, where the lifetime is less than 1 ns, makes it possible to achieve the wave front reversal of pulses with a duration of greater than 0.5 ns with a reflection coefficient of greater than 10 percent. A theoretical interpretation is given of the experimental results. Figures 6; references 6 Russian.
[30-8831]

USSR UDC 621.378.35

INFLUENCE THAT MISALIGNMENT OF THE ELEMENTS TO BE MATCHED HAS ON THE EFFICIENCY OF COUPLING INJECTION SEMICONDUCTOR LASER RADIATION INTO OPTICAL FIBERS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 6, No 8, Aug 79 pp 1761-1766
manuscript received 22 Mar 79

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[Abstract] In coupling injection laser emission into optical fibers, problems arise that are due to the divergence of the laser beam and the strong ellipticity of the far field of the laser radiation. Without special matching, only 20-40% of the emission power can be coupled into multimode fibers, and only 3-5% into single-mode fibers. Previous research has shown that a section of gradient-index light guide can considerably increase the effeciency of coupling injection laser radiation into optical fibers. In this paper an examination is made of the influence that a deviation from coaxiality of the optical elements has on the efficiency of matching. It is shown that there are no qualitative differences in the requirements for alignment of the elements to be matched with or without a section of gradient-index light guide. The authors thank V. V. Nikitin for useful discussion of the results. Figures 3, references 9: 3 Russian, 6 Western.
[24-6610]

USSR UDC 621.391.029.7

INVESTIGATION OF THE WAY THAT THE PASSBAND OF A MULTIMODE FIBER-OPTICS LIGHT GUIDE DEPENDS ON CONDITIONS OF EXCITATION

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 6, No 8, Aug 79 pp 1767-1770
manuscript received 20 Oct 78

BUBNOV, M. M., GRUDININ, A. B., DIANOV, Ye. M. and SENATOROV, A. K., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR, Moscow

[Abstract] An investigation is made of the way that the passband depends on conditions of excitation of light guides developed jointly by the Institute of Chemistry and the Lebedev Physics Institute of the USSR Academy of Sciences. These light guides are made by chemical deposition from the gas phase. Approximate formulas that express the dependence of the passband of the light guide on conditions of excitation are derived on the basis of an analytical expression for the transfer function of a light guide with step-graded index of refraction. This relation is

experimentally studied. The method developed enables measurement of the passband of light guides with index of refraction distributed over the cross section. Figures 4, references 6: 1 Russian, 5 Western.
[24-6610]

USSR UDC 621.396.22.029.7

LONG-DISTANCE WAVEGUIDE TRANSMISSION OF IMAGES IN COHERENT LIGHT

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manuscript received 23 Jan 79

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[Abstract] Based on the example of a cylindrical waveguide with square-wave medium the author shows the theoretical possibility of transmitting optical images to great distances over multimode waveguides (from hundreds of meters to a few kilometers). Expressions are derived that determine the location of long-range cross sections where the image is formed, and the number of image elements that can be transmitted to these sections. Requirements are formulated for the source of emission with consideration of chromatic aberrations of the waveguide. The author thanks L. A. Rivlin and S. D. Yakubovich for interest in the work and useful discussion. References 3: 1 Russian, 2 Western.
[4-6610]

SUPERCONDUCTING PROPERTIES OF GERMANIUM UNDER HIGH PRESSURE

Leningrad FIZIKA TVERDOGO TELA Vol 21 No 8, Aug 79 pp 2321-2324 manuscript received 6 Mar 79

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[Abstract] The results are given of a study of the superconducting properties of the high-pressure phase of germanium with different conductivity types and initial concentrations of carriers. Samples of p- and n-type Ge were used with a carrier concentration in the range of 10^{12} to 10^{19} cm^{-3} under a pressure of from 8 to 13 GPa. Measurements were made with a special fixed pressure unit in which the high-pressure cell was in the form of three pyrophillite disks between which were placed two samples, each of which was supplied with four electric leads to the high-pressure region. This made it possbble in a single experiment to make a simultaneous measurement of either two samples of Ge with different initial concentrations or of one sample of Ge together with a reference metal such as Bi, Sn or Ba. The Ge samples were cut out by the electrosparking method from single-crystal bars and were then etched. The transition into the superconducting state was recorded by the drop in resistivity to zero in a sample compressed at room temperature to a specific pressure. The dependences are shown, of the temperature of the superconducting transition, T_c, on the pressure, P, for all the Ge samples studied. In the low-pressure region the $T_c(P)$ dependence grows rapidly with an increase in pressure. At a pressure of about 9 GPa linear dependences of $T_c(P)$ are observed with negative values of dT_c/dP different for samples with different initial concentrations of charge carriers. In the pressure range of 9 to 13 GPa the value of the critical temperature, T_c, with the same pressure varies nonlinearly both for p- and n-type Ge as a function of the value of the initial concentration of carriers. Dependences of dT_c/dP on the value of the initial concentration of charge carriers are plotted for samples of Ge of both types, where it is shown that in the concentration range of 10^{14} to 10^{17} cm^{-3} extrema are observed. The relatively great changes in the value of T_c with a change in impurity concentrations of a relatively low value make it possible to suggest that the electron spectrum of the Ge II phase is most likely the spectrum of a semimetal or of a degenerate semiconductor. In an earlier study, a radiograph of a sample of germanium obtained at a pressure of about 9 GPa showed the presence of only two phases, i.e., the original Ge I and Ge II high-pressure phases belonging to the beta-Sn structural type. The manifestation of the dependence of dT_c/dP found on the impurity concentration, in addition to the nonlinear dependence of the critical temperature T_c on the concentration, is caused by the influence on superconducting properties of changes taking place in the electron-phonon structure of the high-pressure phase of Ge. Figures 3; references 11: 6 Russian, 5 Western.
[29-8831]

INFLUENCE OF DIELECTRIZATION OF ELECTRONS ON OPTICAL PROPERTIES OF SUPERCONDUCTORS

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 21 No 8, Aug 79 pp 2351-2359
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[Abstract] A study is made of the influence of the dielectrization of electrons on the optical properties of semiconductors. The study consists of two sections. In the first, optical properties are discussed of a system with simultaneous electron-electron and electron-hole pairing at $T = 0^{\circ}C$. The reference is a model of a doped semimetal which is unstable in relation to electron-hole and Cooper pairing. In the limiting case of the semimetal's dielectric gap's being much smaller than the Debye frequency, which in turn is much smaller than the Fermi energy, the reciprocal influence of Cooper and dielectric pairing results in reordering of the entire spectrum of elementary excitation. The second section discusses the absorption of light in this system with other limiting conditions, i.e., with the Debye frequency much smaller than the shift in the Fermi level resulting from doping, which in turn is much smaller than the dielectric gap. In this case, after the dielectric transition the excess of carriers present because of doping remains above the gap and the system is a degenerate semiconductor. A superconducting gap is formed at the chemipotential level in the dielectric phase and causes reordering of the spectrum only near the chemipotential, and here electrons of the completely filled valence band do not participate in superconducting pairing as in the previous case. In the first case reordering of the entire spectrum of elementary excitation in the dielectric phase resulting from the superconducting transition results in the appearance of four branches in the excitation spectrum. In the absorption of light, optical transitions between different branches in the elementary excitation spectrum are shown to be possible, in addition to processes with the breaking of a Cooper and electron-hole pair. This phenomenon is illustrated by the appearance of two breaks on the absorption curve. In the second case, where superconducting reordering of the spectrum takes place only near the level of the chemipotential in the dielectric phase, the absorption coefficient as a function of frequency, depending on the ratio between the Debye frequency, the shift in the Fermi level resulting from doping, and the dielectric gap, can have a peak slightly higher than the threshold frequency. The compounds studied here, in which the superconducting transition is preceded by a structural one, represent the most high-temperature superconductors. The results obtained can be used for a qualitative description of the optical properties of doped superconducting semiconductors of the A_4B_6 (GeTe, SeTe) group in which structural transformation has been observed. Superconducting pairing is possible if the Fermi level after dielectric pairing is just partly beyond the dielectric gap, which occurs with the existence of an elevated density of states

resulting in the possibility of a substantial increase in the superconducting temperature. Figures 3; references 18: 12 Russian, 6 Western.
[29-8831]

USSR UDC 537.312.62

INVESTIGATION OF THE HIGH-FREQUENCY PROPERTIES OF SUPERCONDUCTING POINT CONTACTS IN THE FAR-INFRARED REGION OF THE SPECTRUM

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manuscript received 1 Dec 78

BASOV, N. G., BELENOV, E. M., VEDENEYEV, S. I., GUBIN, M. A., MOTULEVICH, G. P., NIKITIN, V. V., SPETANOV, V. A. and USKOV, A. V., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR, Moscow

[Abstract] A theoretical and experimental investigation is made of the high-frequency properties of superconductive Nb-Nb point contacts that operate under nonequilibrium conditions with high critical current I_c and low resistance of the normal state R_N to study the feasibility of using them for metrology in the near infrared. It is shown that when such contacts are exposed to external emission, their current-voltage curves show obvious current steps that correspond to the harmonics of the external signal frequency at voltages that exceed the limit for niobium superconducting point contacts. In this case, a capacitive frequency limit appears. Weak links with dimensions of no more than 50 nm show frequency multiplication right up to $8 \cdot 10^{12}$ Hz (about 38 μm). An investigation is made of the way that the stepped structure of the current-voltage curve depends on the power and frequency of the external signal, and also the way that the amplitude and linewidth of the intermediate frequency signal depend on the bias voltage and power of the external signals when the contacts are exposed to emission from two sources. Theoretical analysis shows that in frequency multiplication and mixing by superconducting point contacts that operate in the nonequilibrium mode it is necessary to account for the effect of both the emission itself and its harmonics. Figures 12, references 16: 8 Russian, 8 Western.
[24-6610]

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